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OPISTHOBRANCHS FROM AMERICAN ATLANTIC WARM WATERS

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ABSTRACT

In the winter of 1958/1959 Dr. Diva Diniz Corrêa, fellow of the Guggenheim Foundation, collected 25 opisthobranch species and one prosobranch (*Lamellaria*) in the Miami area. Of these 72 per cent are known from the coast of São Paulo, Brazil; hence Hedgpeth's inclusion (1957) of Southeast and South Florida in the same littoral province as Brazil is confirmed by the opisthobranchs. Of the 5 new species one is allied to boreal Atlantic and Pacific species, testifying to the Tertiary Caribbean-Pacific sea connection, and another belongs to a genus known only from the Indo-Westpacific. Of the Miami-São Paulo opisthobranchs, 11 per cent have a transatlantic distribution explainable by the much narrower ocean in the Tertiary. As the opisthobranch fauna of Miami is so similar to that of São Paulo, four species from Brazil were added, one of which (*Rhizorus persimilis*) was already known from Florida. The anatomy of this radulaless species is described for the first time.

INTRODUCTION

The following paper contains chiefly the report of the collection made in the winter of 1958-59 at The Marine Laboratory, University of Miami, by our friend Docent Dr. Diva Diniz Corrêa under a fellowship of the John Simon Guggenheim Memorial Foundation. The relationship between the fauna of Southern Florida and Middle Brazil justifies the addition of four species from Rio and São Paulo, one of which is already known from Florida. One lamellariacean prosobranch is mentioned, because these slugs, since Bergh's monograph (1853), are traditionally collected and studied together with opisthobranchs. The last term is used in a popular sense, excluding pteropods, pyramidellids, and pulmonates. Readers interested in the meaning of the higher systematic categories contained in this paper will find them in Odhner (1939). The few names introduced since then are explained in our text.

If North American students desire to complete the present list and extend it northward and westward to the adjacent coasts, their

model should be MacFarland's (1906) account of the opisthobranchs from Monterey Bay. Classification of boreal opisthobranchs from the North American Atlantic coast will elucidate many species of Gould, Verrill, and others. The difficult but greatly needed anatomical study of the shell-bearing Cephalaspidea can be started with Hoffman's comprehensive work (1932-1940) and Lemche's monograph on *Cylichna* (1956).

To Professor Dr. Gilbert L. Voss we are thankful for correcting the language in the manuscript and reading the proofs.

The animals were well anaesthetized and preserved for histological purposes; the types and representatives of all species from Florida are deposited in the collection of The Marine Laboratory, University of Miami.

EXPLANATION OF LETTERING

- a—ampulla.
- ae—genital aperture.
- ao—caecal ganglion.
- ar—anus.
- as—ascus.
- az—albumen gland.
- b—central nervous system.
- c—gill.
- ca—caruncles.
- cc—buccal ganglion.
- ce—cerebral ganglion.
- ci—ciliated band (sperm groove).
- co—pores.
- cr—canal of seminal receptacle.
- d—spermoviduct.
- e—hermaphrodite duct.
- en—tentacle.
- eu—pleural ganglion.
- f—fertilization chamber.
- g—female gland mass.
- h—hermaphrodite gland.
- i—intestine.
- im—liver branches in lamellae.
- is—penial gland.
- iz—liver branches in parenchyma.
- j—statocyst.
- k—kidney.
- l—limit between removed pharynx and oesophagus.
- m—lateral lamellae.
- ma—male atrium.
- mc—mouth glands.
- me—male duct.
- mi—papilla between caruncles.
- mo—mouth.

- mu—muscles of oral tube.
- mz—male pore.
- n—nidamental duct (and/or) opening.
- ne—pedal ganglion.
- no—nephropore.
- nv—nerve.
- o—oviduct.
- oa—pigment of upper pedal margin.
- oc—pericardial eminence.
- oe—oesophagus.
- om—upper lip.
- on—glands of sole.
- oo—foot.
- or—foot gland.
- p—penis.
- q—penial appendage.
- r—prostate.
- ra—basal plate of radular tooth.
- re—rhinopore.
- ri—ridges of notum.
- ro—opening of rhinophoral pocket.
- rs—rhinophoral sheath.
- s—seminal receptacle (spermatocyst).
- sa—salivary glands.
- sc—oesophageal pouch.
- se—spermatheca (bursa copulatrix).
- si—blood lacuna.
- so—stomach.
- ss—boss or ridge.
- sx—scar of fallen-off ceras.
- t—oral tube.
- u—posterior glands of oral tube.
- uv—transverse furrow of foot.
- v—vagina.
- va—pharynx.
- ve—veil.
- vs—male seminal vesicle.
- w—diverticulum of digestive gland in ceras.
- wa—anal and female aperture.
- wi—digestive gland.
- wo—female aperture.
- x—sphincteres.
- xa—Hancock's organ.
- xz—vesicle of male atrium.
- y—stylet.
- z—eye.
- za—flaps.
- zc—gland of genital aperture.
- zi—spermatocyst (seminal receptacle).
- zo—pylorus.
- zs—parapodium.

SYSTEMATIC SECTION
Order CEPHALASPIDEA
Suborder BULLACEA
Family RETUSIDAE

Rhizorus persimilis (Mörch, 1875)

Figs. 1-6

Occurrence. Near Ubatuba, 135 km east of Santos, in 3-4 m depth on sandy bottom with grey clay and algae, November 12 and 13, 1958, five living snails. Several empty shells on the neighboring shore ("Enseada"). Together with the living *Rhizorus* one *Acteon punctostriatus* (C.B.Ad.) and hundreds of *Cylichnella bidentata* (d'Orb.) and *Tornatina candei* (d'Orb.) were dredged. Anesthetized *Rhizorus* could be preserved well stretched, whilst *Acteon* and *Tornatina* contract.

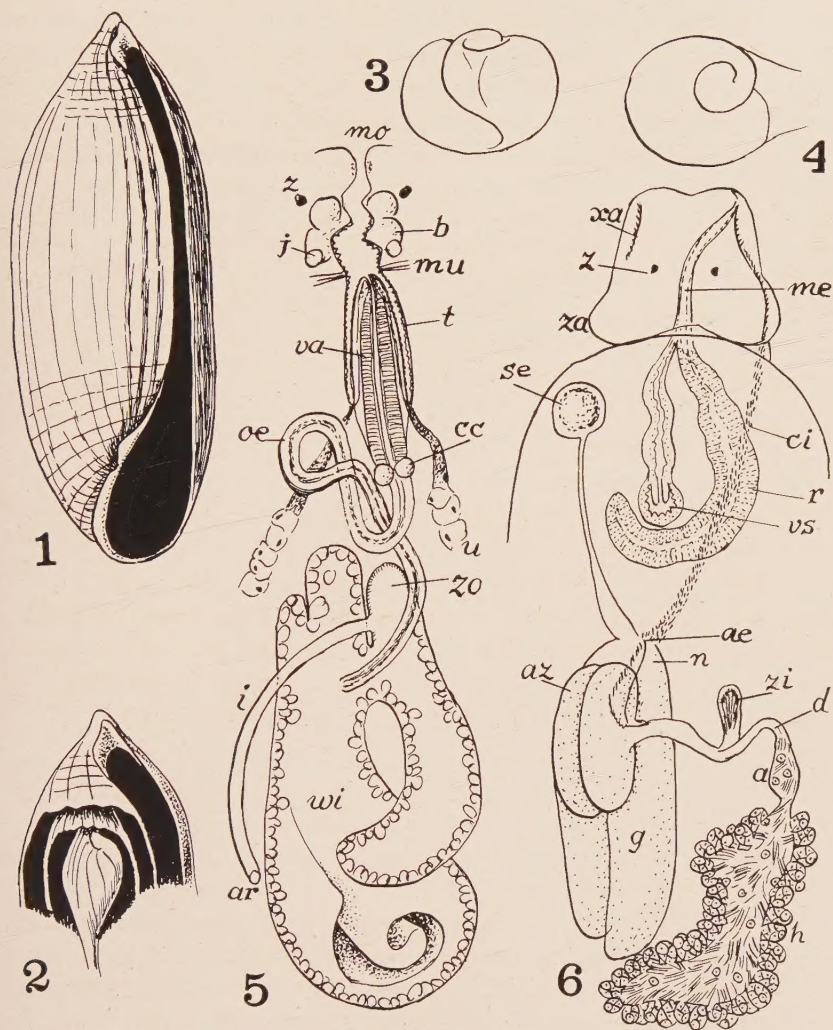
Further distribution. From Cape Hatteras, North Carolina, to Southeast Florida, Cuba, Puerto Rico, Antilles and the coast of Venezuela. In depths from 10 to 800 m.

Description. The present description of the conch refers to the 14 empty shells of our collection, except for the periostracum described from the 5 living snails. The proportion between length and width varies from 1:2.2 to 1:3.25 as shown in the following measurements (in mm):

2.4x1.1	3.3x1.2	3.9x1.35
2.9x1.2	3.6x1.2	4.1x1.4
3.2x1.1	3.7x1.4	4.1x1.4
3.2x1.1	3.8x1.4	4.2x1.4
3.2x1.2	3.8x1.2	

Shell spindle-shaped, white; periostracum transparent with a rust-colored stripe along the inner lip. Body whorl apically more or less produced into either a small spike or a point. Six shells have 4 or 5 and up to 8 fine spiral lines at each end; the others do not show them. Aperture very narrow, as long as the shell. Outer lip thin, following the curvature of the body whorl to beyond the middle, whence it continues in an almost straight line which joins the inner lip in a broad curve. Inner lip reflected over a frail umbilical chink. Columella slightly thickened. About 3 whorls, each of them higher than the previous one.

Larval shell (Fig. 2) completely enclosed in adult shell and similar to that of *Retusa* (Lemche, 1948: 17, 20). Its axis makes



FIGURES 1-6. *Rhizorus persimilis*. FIG. 1. Shell. FIG. 2. Shell opened to show innermost whorl; spire of larval shell directed towards opposite side. FIG. 3. Larval shell isolated from adult shell, side view. FIG. 4. Same, apical view. FIG. 5. Diagram of alimentary tract. FIG. 6. Diagram of reproductive organs. (For lettering of all figures see p. 130.)

about a right angle with that of the adult shell. Its diameter is 0.22 mm, and it has 1.5 whorls. Spire of the larval shell a little elevated; the whorls increase rapidly. Suture relatively flat.

Body capable of being contained in the shell; head shield short,

trapeziform, slightly notched in front and produced backward into two lateral broad flaps (za). Foot small, approximately pentagonal. Its anterior border is straight, the posterior forms a tip, the sides are provided with little salient angles. Cephalic shield and sole covered with thick, dense, basophilous cilia. The cilia of the ciliated male band (ci) and the Hancock's organs (xa) are thinner and stain pinkish. The dorsal surface of the flaps and the furrow between head and foot are not ciliated.

Cutaneous glands are scarce. A large bilobed suprapedal gland, 0.2 mm in length, opens immediately below the mouth into a ciliated pouch, 0-12 mm deep. A similar gland occurs above the mouth opening into a pouch of the same size. Both glands stain intensely blue. The marginal shield glands of *Tornatina*, *Cylichna*, and *Cylichnella* are not developed, nor glands at the inner borders of the flaps or on the anterior border of the foot.

The small eyes (z), 25-28 μ in diameter, lie near the cerebral ganglia, far from the integument. They are equidistant from each other and from the lateral and hind borders of the head shield. The Hancock's organs (xa) are unpigmented and deep pits innervated from about three secondary ganglia on each side.

The mantle is bordered by a 0.2 mm broad belt of large, sub-epithelial acidophilous glands. Contrary to *Cylichna* their ducts are simple pores as in *Cylichnella*. These glands attain their greatest diameter in front of the mantle commissure. Here their innermost row is basophilous. Towards the posterior junction the size of the glands diminishes. The posterior mantle border which passes behind the foot from the left anterior corner to the anterior end of the infrapallial lobe is thin and without glands. This lobe or ventral mantle skirt is thickened and has dense, basophilous cilia on its crest. On its under-side its hind end bears the glandular furrow which produces the columellar callus. On its upper side there are small pink glands. The shell glands on the right or suprapallial lobe are poorly developed; only on the anterior border which is directed transversely are they larger.

The opening of the mantle cavity is not quite as long as the aperture of the shell. The cavity occupies the dorsal surface of the visceral sac. In front it is limited by the mantle commissure or anterior adherence. At the hind border of the latter lies the osphradium. The mantle cavity has a flat simple epithelium with scattered basophilous glands. Even

the hypobranchial gland is composed of only about 5 cells, together 0.1 mm in diameter. Near the hind end of the cavity, roof and floor are coalesced and separate the short pallial caecum which is 0.1 mm in length. The mantle skirts continue backwards outside this coalescence, the posterior adherence. In the posterior left angle of the pallial cavity the anus opens. The genital aperture (ae) is located on the left side, equidistant from fore and hind end of the snail. The ciliated ridges are horseshoe-shaped as in *Cylichna*. They begin on the outer border near the hind end, run forwards, curve inwards and backwards, and terminate in the pallial caecum. The ridges are underlain with blood spaces and bordered with a row of basophilous glands on the convex side. Inside the horseshoe of the ridges there is an area of large, pink staining glands.

The central nervous system (b) lies far in front of the pharynx (va) around the oral tube, but the visceral loop is rather long. The cerebral and pleural ganglia are more approached to each other than in *Cylichnella bidentata*. The cerebral commissure is shorter than the pedal one. Near to the latter lie the statocysts, 40-50 μ in diameter. The cerebro-buccal connectives are longer than in *Cylichnella* (Marcus, 1958a; Fig. 13, bu), as the buccal ganglia (cc) are located over the hindmost end of the pharynx. A right parietal ganglion is applied to the right pleural ganglion at the root of the visceral loop, while the small left parietal ganglion is situated in the left cord as in *Cylichnella*. Posteriorly the loop is twisted. The supra-intestinal ganglion is distinctly anterior to the subintestinal ganglion, and the cord that comes from the supra-intestinal ganglion runs to the left. It contains two small accessory ganglia. The abdominal ganglion close to the subintestinal ganglion and the farther distant genital ganglion lie as in *Cylichnella*.

The mouth (mo) is situated between the infundibular glands (Hoffmann, 1935: 503), viz. the suprapedal gland and its dorsal counterpart. The oral pit is separated from the oral tube by a sphincter. The tube is narrow and lined with an irregular, evidently extensible epithelium underlain by muscle fibres. Behind the nerve ring (b) the tube widens and becomes cuticularized. The cuticle is thrown into thicker transverse and finer longitudinal folds. The nuclei of the subjacent epithelium are scarce; the muscles are stronger than in the precerebral part, and their nuclei are seriate. The oral tube is fastened to the body wall by radial muscle fibres (mu) which insert halfway in a circle. The posterior half of the oral tube (t) is cuticularized and

epithelial, too, and functions as eversible sheath of the pharynx (va).

The tubular pharynx is 0.4-0.5 mm long; its lumen is a vertical slit; its lining a cuticle with longitudinal ribs secreted by a distinctly nucleated epithelium. The pharyngeal layers following outwards are: annular muscles, radiate muscles which do not attain the tip, longitudinal muscles whose nuclei are scarce, a low epithelium, and blood lacunae crossed by oblique muscle fibres. Applied to the pharynx run blue-staining epithelial glandular ducts. The next layers belong to the oral tube which is bent inward. They are: a distinct epithelium, a thin layer of longitudinal muscle fibres, a low epithelium, and a cuticle.

The oral tube revolves around the circle of attachment. Thereby the fundus of the oral tube becomes level with the mouth, and the pharynx is protruded like a pleurembolic proboscis. Thick short muscle cells form a layer on the dorsal side of the neck, between head shield and septum. Their attachments to the body wall are furcate. The length of these cells is about 0.2 mm, their diameter up to 40 μ . Their mantle of fibrils is thicker than the inner sarcoplasma with its central nucleus. Contraction of these muscles diminishes the volume of the cephalic cavity and therewith probably contributes to force the pharynx out of the mouth.

The glandular ducts applied to the pharynx open at the tip of the latter into the oral tube. Hence these ducts belong to "Mundröhrendrüsen" (Hoffman, 1938: 907); true salivary glands were not seen. The oral glands (u) are long tubes 0.5 mm in diameter composed of enormous cells up to 0.1 mm in length with 15-20 μ long nuclei. The hind end of the pharynx projects backwards beyond the oral tube; it is indicated by the buccal ganglia (cc) and continued into the long oesophagus.

The oesophagus (oe) is narrow, ciliated, coiled in front and straight behind. It enters the digestive gland (wi) without forming a preceding stomach. The liver extends partly forwards, partly backwards. From the anterior diverticulum two lobules are separated by constrictions, a small one running forwards and a large one whose anterior part functions as pylorus (zo), while its posterior, truly hepatic caecum runs backwards and ends in the innermost whorl of the snail. Pylorus and intestine are ciliated and full of diatoms. The intestine (i) begins with a small loop, not drawn in Figure 5. Skeletons of diatoms occur also within the digestive cells, whose various stages correspond to Fretter's description (1939: 605-06). Between these big cells, Lemche's typical liver cells (1956: 85), occur smaller ones, triangular in

transverse sections and attached to the basement membrane with their broadest side. They contain dark granules and may be excretory.

The gill is a short undulate triangle. The heart lies in the roof of the pallial cavity to the left and in front of gill and kidney. The detorsion of the heart is nearly complete, because the ventricle is obliquely in front of the auricle as in *Philine* (Guiart, 1901: Fig. 24 on p. 67). A broad blood gland lies over the aorta as in *Cylichnella bidentata* (Marcus, 1958a: Fig. 11, be). The blood spaces in the kidney are disposed longitudinally just as those in *Cylichnella* (*l.c.*, p. 6) and *Cylichna* (Lemche, 1956: 103-4, Fig. 344).

The hermaphrodite gland (h) lies between the posterior diverticula of the intestinal gland (wi). The small outer female lobules and the central male follicle are as in *Cylichna* not clearly separated. A spacious ampulla (a) contains male and female germ cells. The spermoviduct (d) communicates with the short canal of the spermato-cyst (zi) or seminal receptacle, in which the sperms are attached to the wall. The corresponding organs of *Cylichna* (Lemche, 1956: Pl. 43, fig. 352) and *Tornatina* (Marcus, 1956a: 40) occupy the same position. The ectal course of the spermoviduct is glandular. A band of cilia begins within the duct, where the latter dilates into the female gland mass (g). This mass consists of a smaller albumen gland (az) and a bigger subjacent mucous gland. The gland extends along the intestine (i) and the liver (wi).

Two apertures separated by folds lie near together at the fore end of the mucous gland. One, the nidamental opening (n), opens into the pallial cavity. The other, the genital aperture (ae), contains the ciliated band and is united with the opening of the spermatheca (se). The duct of the latter is ciliated and extends to the left along the junction of floor and bottom of the pallial cavity. This duct begins folded and wide and narrows towards the small vesicle of the spermatheca (se). This is situated in front of the heart and contains an irregular mass of sperms and prostatic secretion, as is the rule in a bursa copulatrix.

A band of cilia (ci) beginning at the genital aperture (ae) traverses the floor of the pallial cavity, runs along the right furrow between foot and cephalic shield like a sperm groove and passes through the Hancock's organ. It merges into a male duct (me) which penetrates into the cavity of the head and leads the sperms to their reservoir. The duct runs backwards and bifurcates dorsally to the nerve ring forming two ample tubes of different length. The longer

and broader one is a prostate (r). The shorter and narrower one consists of two parts, an inner seminal vesicle (vs) and an outer tubular part whose epithelium contains red staining secretion. Both parts are separated from one another by a valve which projects inwards. In the tubular part it seems that a spermatophore is produced. This must be released from the male pore, i. e. the point where the male duct (me) opens and communicates with the superficial ciliated band (ci).

Discussion. As in other genera whose anatomy is unknown, the distinction of the species is difficult and uncertain in *Rhizorus*. Dall (1889: 51) considered it as highly probable that *persimilis* (Mörch, 1875: 179) and *oxytatus* (Bush, 1885: 468) were identical. Pilsbry (1893: 236) did not express an opinion on this synonymy. Dautzenberg (1900: 156) vividly opposed Dall's view. He had however only a single shell from the coast of Venezuela and called it *persimilis*. Of course he could not evaluate the range of variation. The proportion between height and width, the more or less pointed apex, and the indistinct spiral lines vary even in our small number of shells, though they all come from the same locality. The narrow aperture of our shells agrees better with Dautzenberg's figure (Pl. 9, Fig. 10) than with that of Bush (Pl. 45, Fig. 12). But as the aperture of *oxytatus* was described as very narrow, and Dall and Simpson's figure (1901: 57, Fig. 8) of a shell from Puerto Rico determined as *oxytatus* agrees with our material, we think that *oxytatus* is really conspecific with *persimilis*.

The synonyms of the type of the genus, *R. acuminatus* (Bruguière, 1789), were well established by Lemche (1948: 80). The distribution of this species (Odhner, 1907: 45) comprises the Eastern Atlantic, from the Trondheimfjord where it was found in the stomach of a haddock (Nordgaard, 1928: 153) to Gibraltar, the Mediterranean (Vayssière, 1885: 31) and Adriatic Sea, and the Gulf of Suez. Within the same area Pilsbry (1893: 235) distinguished a variety, *brevis*, with stumpier and broader shell. This is evidently only a form of growth. Pruvot-Fol (1954: 46) considered *oxytatus* as a variety of *acuminatus*. But the latter has denticles arranged in a horseshoe-like line (Thiele, 1925: 269) in a not yet defined part of the fore-gut and thus differs specifically from *persimilis* without such denticles. Both species agree in the absence of gastric plates (Odhner, 1939: 10: *acuminatus*), and in the shape of the shell.

It is possible that the West Atlantic "spindle bubbles" (Abbott,

1955: 280-81) belong to two species which differ by the form of the outer lip and the umbilical chink. To *R. persimilis* (Mörch, 1875) we suggest to refer: *oxytatus* (Bush, 1885: 468), *bushii* (Dall, 1889: 51; 1925: Pl. 25, Fig. 3), *mörchi* (Dall, 1927: 22), and *ischnatractus* (Pilsbry, 1931: 301), the last from the Bahamas. Synonyms of *R. acutus* (d'Orbigny, 1841) may be: *minutus* (Bush, 1885: 469) and *aspinosus* (Dall, 1889: 51; 1925: Pl. 25, Fig. 5).

The genus *Rhizorus* must be provisionally preserved in the family Retusidae. It agrees with *Retusa* in the form of the cephalic shield, foot, and larval shell, as well as in the absence of jaws and radula. The absence of gizzard plates distinguishes *Rhizorus* from *Retusa*. As the anatomy of the last genus is nearly unknown, other tectibranchs without jaws and radula, Pyramidellidae (Fretter and Graham, 1949), Cymbuliidae (*Corolla*, *Gleba*), and Aglajidae must be compared with *Rhizorus*. None of these families can receive the genus. Its digestive gland shows similarity with that of the Philinoglossacea. The long oral tube, proboscis-like pharynx, and digestive gland with spacious lumen without stomach of *Rhizorus* lead also to the Pyramidellidae and Pseudothecosomata (*Desmopterus* without gizzard plates). But for no organ can a true homology be established.

Suborder PHILINACEA

Family GASTROPTERIDAE

Gastropteron rubrum (Rafinesque, 1814)

Figs. 7-8

Principal references. Krohn, 1860: 64-68, Pl. 2, Figs. 2-3 (larval shell); Vayssière, 1879-1880: 11-72, Pls. 1-6 (anatomy); id. 1885: 39-43, Pl. 2, Figs. 35-41; Bergh, 1893: 284-303, Pls. 16-17; Pelseneer, 1894: 14-16, Pl. 5, Figs. 36-42; Pilsbry, 1895: 40-41 (literature), Pl. 7, Figs. 1-10, Pl. 8, Figs. 11-13, 16 (figures from Souleyet, Vayssière, and Bergh).

Occurrences. 1. Biscayne Bay, February 2, 1959, one swimming slug caught by Mr. Robert C. Work. UMM 30.1827. 2. Ilhabela, coast of S. Paulo, Brazil, June 8, 1953, one slug caught with the plankton net near the shore.

Further Distribution. Florida, Gulf coast (Abbott, 1955: 284) and Atlantic coast (Dall, 1889, quoted from Pilsbry, 1896: 239); Guadeloupe (Dall, *ibid.*); Atlantic coast of Morocco; Southern coast of Portugal, 233-300 m; Gulf of Gascony, 50-120 m; Mediterranean Sea (frequently at 50-80 m) inclusive the Adriatic and Aegean Sea.

Remarks. Though often swimming, *G. rubrum* is not a pelagic slug, but an inhabitant of the bottom and generally taken with the dredge. Animal substances (Vayssière, 1879-1880: 12; Bergh, 1893: 298) and phytoplankton (Graham, 1955: 153) are recorded as food.

The larger of our specimens, that from Biscayne Bay, preserved was 3 mm long, 2 mm high, and 4 mm broad with expanded parapodia. The animal bears purple spots and has bluish white borders around the head shield, the parapodia, and the hind end of the foot. The examined radula from S. Paulo agrees with Vayssière's figures (1885: Figs. 39-41), while the lateral tooth of Risbec's material (1931: Figs. 66, 67) is somewhat different.

Family AGLAJIDAE

According to White (1946: 91, note 1) *Aglaja* Renier, 1804, is a nomen nudum, so that it is not necessary to follow O'Donoghue (1929b: 11) in substituting *Aglaja* Renier, 1807.

Chelidonura evelinae Marcus, 1955

Fig. 9

Occurrence. Biscayne Bay, between Miami and Miami Beach, MacArthur Causeway, among algae, November 24, 1958, one slug. UMML 30.1824.

Further Distribution. Coast of S. Paulo, Brazil.

The preserved specimen was 8 mm long and 4 mm in diameter; full grown living animals attain 40 mm in length and 7 mm in breadth with closed parapodial lobes. The row of metallic blue spots bordered with black rings on the margins of the parapodia characterize this sole Western Atlantic species of the genus (Marcus 1955a: 101). The number of these spots increases with age. The shape of the posterior mantle lobes varies; they may be doubled.

In order to keep the animal entire for the Miami collection it was not dissected.

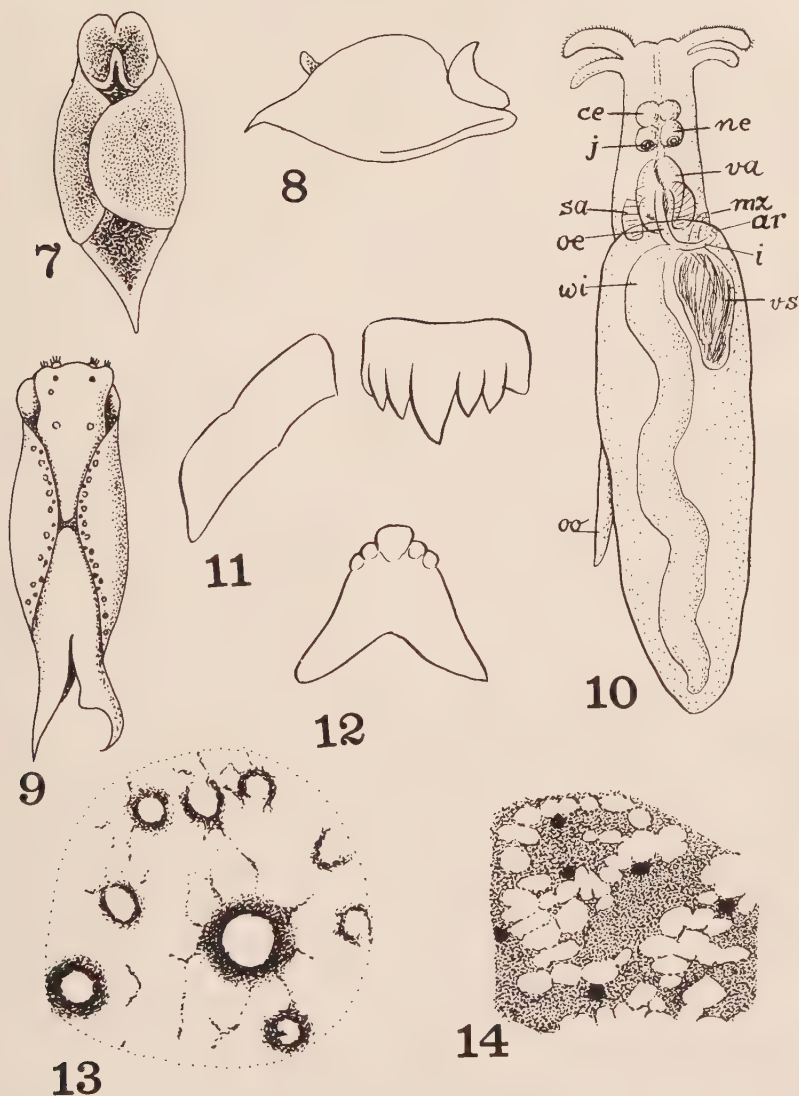
Order ACOCHLIDIACEA

Family MICROHEDYLIDAE

Unela remanei Marcus, 1953

Figs. 10-12

Occurrence. East coast of Virginia Key, Virginia Beach, in coarse sand, December 9, 1958, seven slugs, males and females. UMML 30.-1800.



FIGURES 7-8. *Gastropteron rubrum*. FIG. 7. Dorsal view of living slug from S. Paulo. FIG. 8. The same, lateral view. FIG. 9. *Chelidonura evelinae*. Living animal from the coast of S. Paulo; the black rings indicate the brilliant blue spots. FIG. 10. *Unela remanei*. Dorsal view of living slug, from a sketch by the collector. FIG. 11. Half row of radula. FIG. 12. Median plate. FIG. 13. *Aplysia dactylomela*. Color pattern, natural size. FIG. 14. *Aplysia cervina*. Color pattern of a young specimen, magnified.

Further Distribution. Coast of S. Paulo, Brazil, in coarse sand of the lower intertidal zone (Marcus, 1953: 172).

The animals are 2 mm long, hence smaller than those from the Brazilian coast (3-5 mm). However they belong to the same species as is evidenced by the radula and the presence of eyes (in contrast to *U. odhneri* Marcus, 1911b: 211). The median plate is provided with a central cusp flanked by two denticles on each side, and the basal half of the lateral plate bears a slight point on the anterior border.

Order ANASPIDEA

Family APLYSIIDAE

Subfamily Aplysiinae

Aplysia dactylomela Rang, 1828

Fig. 13

Principal references. Rang, 1828: 56, Pl. 9 (*dactylomela*); *ibid.*, Pl. 10, Figs. 1-3 (*protea*); Pilsbry, 1895: 75, Pl. 32, p. 78, Pl. 37, Figs. 20-22 (older literature and figures); MacFarland, 1909: 14-37, Figs. 1-14 (anatomy); Engel and Hummelinck, 1936: 5-13 (comparative description); Macnae, 1955: 226-221 (distinction of subspecies); Marcus, 1955c: 14-15 (Brazilian localities); 1959b (reproductive organs).

Occurrence. East coast of Virginia Key, Virginia Key Beach, during low tide dug into the mangrove mud, November 10, 1958, 40-50 slugs.

Further distribution. Excluding *A. dactylomela* var. *fimbriata* Adams and Reeve, 1848, the typical form is confined to the Atlantic Ocean between 35° N and 35° S. The coast of Morocco and the islands of Bermuda indicate the limits of its distribution to the north. To the south the eastern limit is the coast of South Africa. The western limit, the coast of S. Paulo, Brazil, is probably provisory, because a thermal restriction can hardly be expected between 25° and 35° S.

Remarks. Dr. Diva Diniz Corrêa identified these sea-hares characterized by their black or sepia brown rings (Fig. 13), but did not collect any material, because the species is very well known and the handling of the bulky animals troublesome.

In *A. dactylomela* var. *fimbriata* Adams and Reeve, 1848, from the Indian Ocean the rings are smaller than in the Atlantic specimens, and the tentacles are larger and more fimbriated. There are, however, intermediate specimens (Macnae, l. c.), and it may well be that the

occurrences of the two forms overlap on the southern coast of South Africa. Therefore it is probably most correct to follow Dr. Nellie B. Eales (Reading, England: letter of May 9, 1956) who gives the eastern species the rank of a variety. If Macnae (1955: 226) was right in that *A. tigrina* Rang (1828: 57, Pl. 11) is identical with *dactylomela*, *tigrina* would have priority over *fimbriata*. But we do not think that Rang's figures permit positive identification.

Aplysia cervina (Dall and Simpson, 1901)

Fig. 14

Occurrence. East coast of Virginia Key, in front of The Marine Laboratory, University of Miami, under a log in the tidal zone, February 2, 1959, two slugs. UMML 30.1822.

Further Distribution. Charleston, South Carolina (Eales, 1957: 246); Puerto Rico (Dall and Simpson, 1901: 365); Curaçao (Engel and Hummelinck, 1936: 13); Brazil, coast of Alagoas (MacFarland, 1909: 38) and S. Paulo (Marcus, 1959b: 3).

Remarks. Possibly also the northern coast of Yucatan belongs to the localities of *cervina*, because *Tethys* (*Aplysia*) *pilsbryi* Letson (1898: 193) may be identical with the present species. But as long as Letson's material or specimens from Yucatan are not reexamined, the newer name should be used.

MacFarland (1909: 38-57, Figs. 15-35, 39-42) monographed *A. cervina*, whose general aspect was drawn by Dall and Simpson (1901: pl. 56, Fig. 2). The present specimens are young, 17 and 20 mm long when preserved. They show the scattered dark round spots on the sides (Fig. 14), and the parapodia low on the roof of the short foot.

The color as well as anatomical features distinguish *A. cervina* from *A. brasiliiana* Rang, 1828 (Marcus, 1955c: 4-14). Eales (1957: 246) considers *A. floridensis* (Pilsbry, 1895: 246) as a darker variety of *brasiliiana* with somewhat larger parapodia, but we have seen very dark *brasiliiana*, and the parapodia are not specially broad in Pilsbry's figure (Pl. 37, Fig. 19).

The parapodia joined low down posteriorly distinguish *cervina* from *A. (Tullia) juliana* Quoy and Gaimard, 1832. This latter species was described as *A. (Metaplysia) badistes* Pilsbry, 1951, from Biscayne Bay; Macnae (1955: 237), Engel and Eales (1957: 110-111), and Eales (1957: 248) established the identity of *badistes* with *juliana*, though the armature of the penis has yet to be investigated in *badistes*.

Order ASCOGLOSSA
Suborder *ELYSIACEA*
Family HERMAEIDAE
Subfamily Stiligerinae

As the names of families are not bound to the name of the oldest genus it was unnecessary to change the name Hermaeidae (e. g. Fischer, 1887: 542; Eliot, 1910: 176; Odhner, 1939: 12) to Stiligeridae (O'Donoghue, 1929: 738).

Stiliger (Stiliger) vanellus Marcus, 1957

Figs. 15-17

Occurrence. East coast of Virginia Key in front of The Marine Laboratory, University of Miami, among algae, December 8, 1958, one slug. UMML 30.1830.

Further Distribution. Coast of S. Paulo, Brazil.

Remarks. The preserved animal is 1.6 mm long and 1.2 mm broad and high without the cerata which attain 0.9 mm. It has 10 right and 9 left cerata.

The color differs from the 3 original specimens (Marcus, 1957: 402) in the absence of dorso-lateral and dorsal white areae. The entire skin contains melanophores which are biggest in the hind part of the back and densest on the anterior border of the foot. On the cerata, white glands shine through the skin. Since our first description we obtained 4 further specimens from the coast of S. Paulo, two of which are spotted all over. One of these has scattered big melanophores in the same region as the Floridian animal.

The teeth of the radula and the penial stylet agree exactly with those of the Brazilian material. The present specimen has five 0.112 mm long teeth in the ascending limb of the radula, seven in the descending limb, and about eight in the ascus.

Stiliger (Stiliger) vossi, spec. nov.

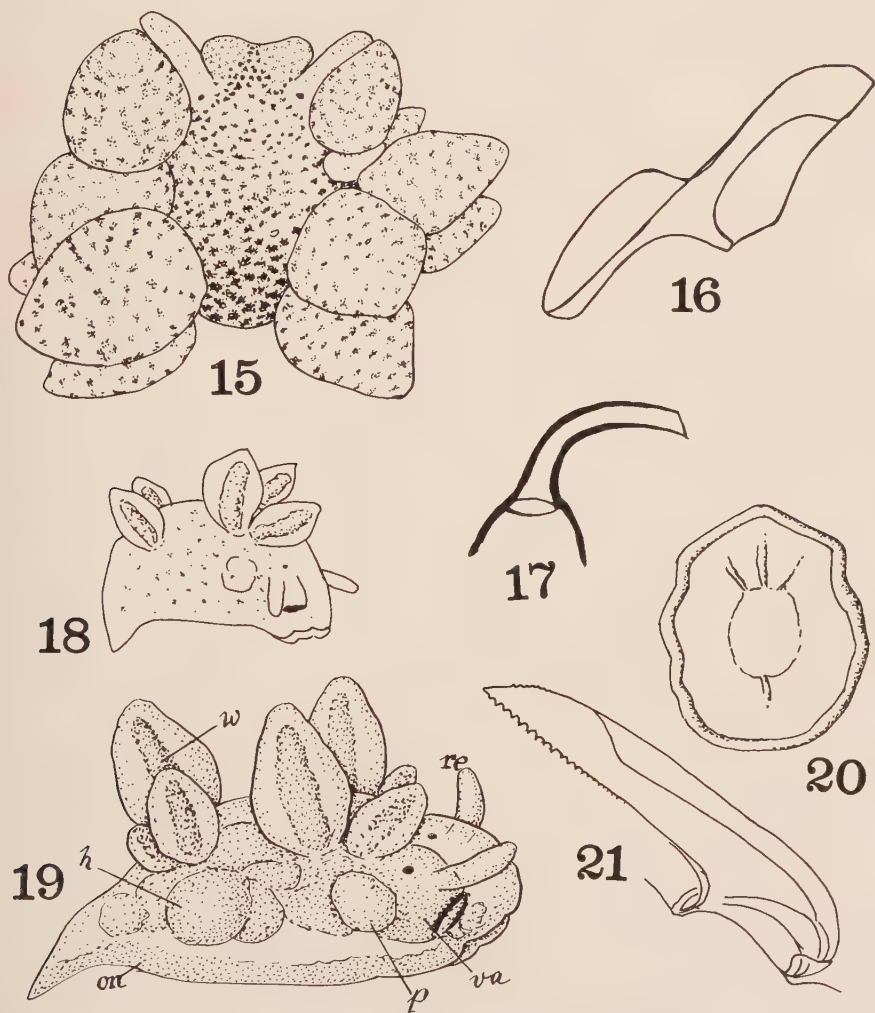
Figs. 18-21

Occurrences. 1. Biscayne Bay between Miami and Miami Beach, MacArthur Causeway, among algae, November 24, 1958, two slugs. 2. East coast of Virginia Key, in front of The Marine Laboratory, University of Miami, among algae, December 4, 1958, one slug. All UMML 30.1801.

Description. The preserved animals are 0.9-1.2 mm, the cerata up to

0.5 mm long, and up to 0.3 mm in diameter. The slugs are white with a small number of melanophores scattered on back and sides.

The smooth rhinophores (re) are round in transverse section. The glands (on) of the sole are markedly developed along the entire



FIGURES 15-17. *Stiliger (Stiliger) vanellus*. FIG. 15. Dorsal view of preserved slug. FIG. 16. Radular tooth. FIG. 17. Penial stylet. FIG. 18. *Stiliger (Stiliger) vossi*. Right side view of preserved slug in alcohol. FIG. 19. Another specimen clarified in oil of cloves. FIG. 20. Isolated cuticle of labial disc. FIG. 21. Radular tooth.

extension of the foot. The anterior end of the foot is rounded with a median notch. The cerata form two groups on either side, the anterior with 2, the posterior with 1-2 cerata. The walls of the diverticulum (wi) of the digestive gland in the cerata are even, not tuberculate. The albumen gland does not enter the cerata.

The labial disc bears a thick brown cuticle visible in the total slugs in alcohol (Fig. 18). The radula consists of 7 teeth in the ascending, 12 in the descending limb, and about 10, every one smaller than that which follows outwards, in the spiral ascus. The teeth are very low, pointed, up to 80 μ long, with a base of 25 μ . The cutting edge is provided with a row of up to 2 μ long denticles, and also the opposite border of the cusp is finely serrate near the tip (Fig. 21).

The globose male copulatory organ (p) was everted in all 3 specimens. It is unarmed, but probably the stylet had been torn off.

The species is named for Professor Dr. Gilbert L. Voss.

Holotype. Whole mount, UMML 30.1802.

Discussion. This species belongs to the section or subgenus *Stiliger*, *sensu stricto*, not to *Ercolania* Trinchese (1872: 87), whose rhinophores are grooved or flattened on the outer side. Besides the recently listed 22 described species of *Stiliger*, *sensu lato* (Marcus, 1956b: 7-8), we now compared *S. (Ercolania) akkeshiensis* Baba (1935: 116). Of the two species from the Indian Ocean whose descriptions were not available, *S. tentaculatus* Eliot, 1917, and *S. gopalei* Rao, 1937, the first can be separated from *vossi* by the characters which Pruvot-Fol (1951: 73) indicated. All other species of *Stiliger* lack the essential characters of *vossi*: radular tooth denticulated at the inner and outer edge of the cusp, and heavily cuticularized labial disc.

The spiral ascus of *S. vossi*, where the teeth retain their position in the series and are not piled up haphazardly, occurs also in *Stiliger smaragdinus* Baba (1949: 32, 129). *Hermaea vancouverensis* O'Donoghue (1924: 19), and in the species of *Hermaeina* (*Aplysiopsis*). The latter genus also has denticulate cutting edges on the radular teeth. But in *Hermaeina* the outer part of the tooth is higher, and the rhinophores are auriculate. Therefore we did not include the present species in *Hermaeina*, whose species are rather uniform.

Stiliger (Ercolania) costai Pruvot-Fol, 1951

Figs. 22-25

Occurrence. Key Largo, among *Padina*, 8. XI. 1958, one slug. UMML 30.1825.

Further Distribution. Mediterranean Sea, Banyuls and Villefranche.

Description. The living animal was white with a dark network, constituted by the liver branches, and dark-red, white-tipped rhinophores. The preserved specimen is whitish.

The length is 3 mm, the breadth about 2 mm, and the height about 1.5 mm without cerata, whose length is up to 0.8 mm.

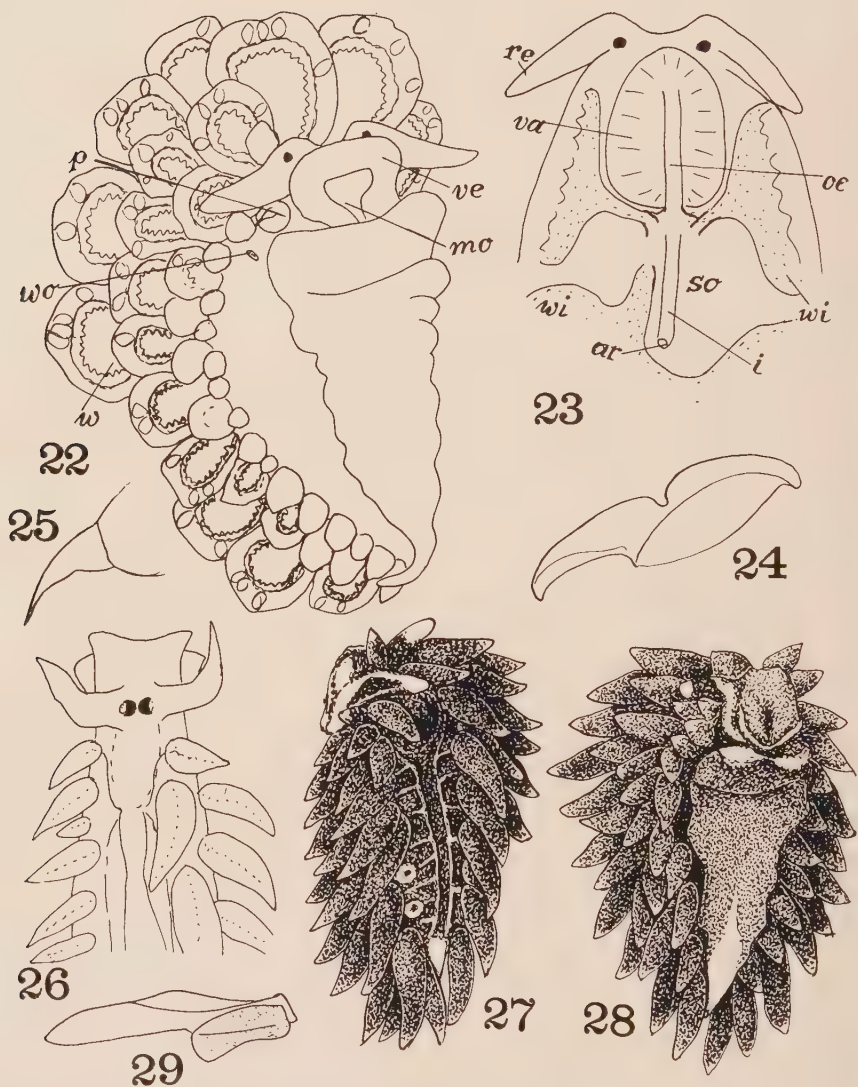
Around the mouth the head is widened, forming a veil (ve), semicircular in outline, whose upper side bears the rhinophores, broad at their bases and with pointed tips. The black eyes of 45-50 μ diameter lie at the posterior borders of the rhinophorial bases. The transverse section of the rhinophores, which are neither grooved nor rolled in, is oval, indicating a flattening on the outer side. The foot has an anterior straight transverse border and is pointed.

The very caducous cerata stand in 3-4 longitudinal rows on both sides and leave the middle of the back free, but touch one another in front. As in other Hermaeidae the innermost cerata are longest. Pruvot-Fol (1954: 196) compared their shape with electric bulbs; in the preserved slug they are a little longer than broad and have blunt ends, not pointed as when alive. They increase in number towards the sides; the outermost row consists of very numerous round buttons. In the cerata the diverticula of the digestive gland are vesicular, and between them and the epidermis of the cerata lie white cutaneous glands. The albumen gland does not enter the cerata.

The mouth (mo) lies under the veil. The enormous pharynx (va) is 0.8 mm long and 0.5 mm broad and contains a radula of 6 teeth. Two of them belong to the ascending, 4 to the descending limb. In the sac-shaped ascus 8 worn teeth are heaped up. The teeth are up to 0.4 mm long, sabot-shaped, with a 0.15 mm long base. Near the anterior end of the cusp the median keel is very high. Liver branches enter the rhinophores and the veil. The anus (ar) is located in the center of the back, equidistant from fore and hind end and from either side.

The male opening is situated immediately behind the right rhinophore, the single female opening (wo) visible on the surface a little behind. The everted penis (p) showed a 40 μ long, very pointed stylet.

Discussion. It was evidently a slip that Pruvot-Fol (1954: 191) included *Ercolania* in the Hermaeinae with rhinophores rolled in. Actually it belongs to the Stiligerinae with flattened or slightly grooved rhinophores. As the flattening on the outer side of the rhinophore can disappear in preserved specimens, as Pruvot-Fol (1951: 70) noted



FIGURES 22-25. *Styliger (Ercolania) costai*. FIG. 22. Preserved slug seen from the right side and ventrally. FIG. 23. Dorsal view of clarified fore end; cerata removed. FIG. 24. Radular tooth. FIG. 25. Penial sylet. FIG. 26. Sketch of fore end of living slug. FIG. 27. Dorsal view of preserved animal. FIG. 28. Dorsal view of same. FIG. 29. Radular tooth.

in the present species, *Ercolania* cannot be maintained as a separate genus. Now that the type of *Stiliger*, *S. ornatus* Ehrenberg, 1831, has been rediscovered (Macnae and Kalk, 1958: 86), one can expect a new description and a better definition of *Stiliger*, which hitherto included species with and without branches of the albumen gland in the cerata. In *Ercolania* the cerata contain only liver diverticula which are unbranched in *E. costai*.

The radula consisting of few enormous teeth, and the hepatic branches entering the rhinophores and the veil were decisive for the classification of the present specimen.

Subfamily Hermaeinae

Costasiella Pruvot-Fol, 1951

Hermaeidae with large eyes which are contiguous and lie between, not behind, the rhinophores; anterior angles of the foot more or less produced; cerata fusiform, containing branches of the albumen gland besides diverticula of the digestive gland; penis unarmed.

Type species. Costasiella virescens Pruvot-Fol (1951: 74).

Of the possibly immature type specimen only the external aspect has been described. But we think that the exceptional position of the eyes in our slugs allow for an allocation to *Costasiella* and a supplement of the diagnosis of this genus.

We do not include the character of the rhinophores of our specimens in this diagnosis. Pruvot-Fol (1954: 198) described them as not rolled up, but flattened as in *Ercolania*. However she had lost her specimen and could not examine it thoroughly.

If *Costasiella* is compared with Thiele's genera of the Stiligeridae (1931: 413-414), *Hermaeina* differs by denticulate radular tooth, *Physopneumon* by absence of branches of the albumen gland in the cerata, and *Hermaea* as well as *Stiliger* by penial stylet. According to the system of Pruvot-Fol (1954: 182-196) *Stiliger* differs from *Costasiella* by cylindro-conical rhinophores which may be flattened on the outer surface, *Hermaea* (synonym: *Physopneumon*) by bifurcate rhinophores, *Placida* by penial stylet, *Aplysiopsis* (synonym: *Hermaeina*) by denticulate radular tooth, *Hermaeopsis* by lateral anus and rhinophorial borders overlapping one another, and *Ercolania* by absence of albumen gland in the cerata.

Costasiella nonatoi, spec. nov.

Figs. 26-33

Occurrence. Near Ubatuba, 135 km east of Santos, on sandy bottom

with clay and algae, November 12, 1958, two slugs in 3 m depth.

Description. The length of the preserved animals is 2 and 4 mm, the breadth of the larger is a little more than 1 mm (not measured because of the cerata), its height 1 mm without the cerata whose length is up to 1 mm. The maximum breadth of the ciliated sole is 1.5 mm at its anterior end.

The larger slug was black in life, stippled with white openings of cutaneous glands. Also the evidently regenerated tail has no pigment. The tips of the cerata are white, and so are the anterior border of the foot and two lateral streaks passing from this border on to the outer side of the rhinophores up to their white tips. Two white contiguous circles around the eyes lie between the rhinophores. In the smaller slug the green digestive gland was not hidden under the dense pigment of the skin.

The head is broadened in front, the rhinophores are grooved along their whole length as in *Placida tardyi* Trinchese (1877-1879: Pl. 14 A, Fig. 5). Level with them a furrow begins which separates the back from the foot as in *Placida* (Pruvot-Fol, 1954: 185), and in the beginning of this furrow a group of sensory cells is localized whose topography corresponds to the Hancock's organ under the head shield of the Cephalaspidea (Marcus 1958a: Fig. 8d). The eyes (z) lie between the rhinophores, and their retinae touch one another. The eye-cups are $80\ \mu$ in diameter in the larger, $70\ \mu$ in the smaller slug; the lenses are relatively small. The central nervous system studied in sections is highly concentrated, without commissures between the cerebropleural and the pedal ganglia. A subintestinal ganglion was not found, as in *Limapontia* (Pelseneer, 1894: 62).

The anterior border of the foot is broad and bilobate; it contains large glands. The fusiform cerata form about 10 not quite regular slanting rows of 5 cerata each; the innermost cerata are largest. The digestive gland does not ramify in the cerata, but forms knobby diverticula. In the larger slug the cerata contain branches of the albumen gland; the smaller animal is in the male phase, and its albumen gland is not yet developed. The liver cells of the hepatic ducts and the diverticula in the cerata lodge zoochlorellae of $4\text{--}6\ \mu$ diameter with a distinct pyrenoid.

The mouth (mo) is flanked by two groups of pigment cells, such as occur in *Stiliger evelinae* Marcus (1959a) and *Elysia evelinae* Marcus (1957: 411). The radula consists of 14 small teeth, up to $50\ \mu$ long, with a dark brown base and smooth cusp. Behind the nerve

collar the oesophagus (oe) passes through a narrow valve and dilates into a muscular, slightly left-sided pouch (sc), homologous with the dorso-lateral oesophageal diverticulum of *Hermaea dendritica* (Fretter, 1941: 193). As in the last species and in *Tridachia crispata* large nerve cells are embedded between the ciliated cells which line the pouch. Also the following stomach (so) is ciliated, and so is the short intestine (i) which leaves it in front and on the right side. The anus (ar) opens in front and to the right of the pericardial eminence. Two posterior gastric tubes are continuous with the liver ducts that lead to the hinder cerata. Zoochlorellae were not observed in the contents of the stomach.

The pericardial elevation is small and lies close behind the rhinophores, ventrally to the renal tube. The efferent vessels from the cerata constitute longitudinal stems on both sides of the dorsal mid line.

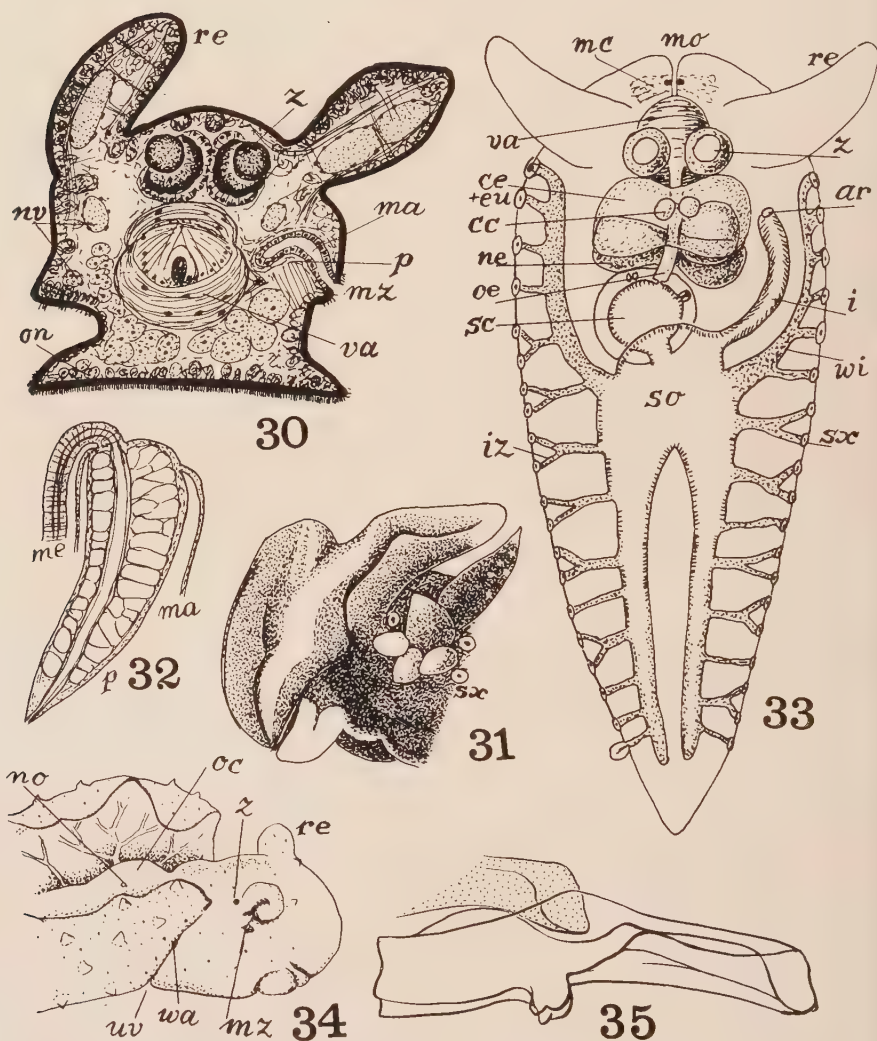
The species is triauleic; the male opening is located ventrally to the right rhinophore, the nidamental and vaginal apertures are close together and a little farther behind. The penis is a pointed glandular cone without a stylet. Pelseneer (1894: 62) noted the absence of a vagina in the very young slugs of *Elysia viridis* with developing male germ cells, and this observation has been frequently quoted. In the smaller of our present slugs still without albumen gland, the vagina is already pervious.

The species is named for Dr. Edmundo Nonato who dredged the material.

Holotype. One slide with series of transverse sections.

Discussion. The color of our smaller specimen agrees with that of *C. virescens*, but this character is taxonomically of little importance. The much smaller number of cerata in *virescens* indicates that the slug was young, though the 2 mm long slug of *nonatoi* has at least twice as many. The foot corners of *virescens* described and drawn (Pruvot-Fol, 1951: Fig. 42, Pl. 1, Fig. 23) as tentaculiform and pointed are rounded and decidedly shorter in *nonatoi*. As both forms were drawn alive, this character can be compared, and upon it the specific difference is based.

It is possible that *Doto* (?) *ocellifera* Simroth (1895: 168) belongs to *Costasiella*. The rhinophores, the arrangement of the cerata in a dorsal and a ventral row, the radula, and the eyes prove that it is not a *Doto* (Odhner 1934: 301). In clarified slugs the outline of the liver diverticula might perhaps be confounded with that of the ceras itself.



FIGURES 30-34. *Costasiella nonatoi*. FIG. 30. Transverse section on level of eyes. FIG. 31. Left rhinophore. FIG. 32. Penis. FIG. 33. Diagram of digestive organs; salivary glands omitted. *Elysia cauze*. FIG. 34. Right side view of fore end. FIG. 35. *Elysia evelinae*. Radular tooth; the following one stippled.

It seems possible thus to interpret the strange warty "dorsal papillae" of *ocellifera*, whose 4 "secondary eyes" are evidently pigment spots beside the mouth and farther behind.

Family ELYSIIDAE

Elysia cauze Marcus, 1957

Figure 34

Occurrence. East side of Virginia Key, in the intertidal zone, November 10 and 25, 1958, two slugs on *Caulerpa*. UMML 30.1826.

Further Distribution. Coast of S. Paulo, Brazil, on *Caulerpa*.

Remarks. The preserved animals are 20 and 13 mm long, yellowish with small black rings and the other previously described black markings (Marcus, 1957: 407). The larger specimen is warty, the smaller one smooth, as was also found among the warty Brazilian slugs. The male aperture (mz) lies at the base of the right rhinophore and in front of the eye (z); the anal opening together with the single female pore is located (wa) in the fold that continues the anterior pedal fold (uv) upwards on the right side.

In 1957 (p. 410) we called *E. papillosa* Verrill (1901: 31) the only other Atlantic species with papillae, but *E. subornata* Verrill (1901: 29) is distinctly, though minutely, papillose too, and papillae also occur occasionally (Engel, 1927: 114) in *E. ornata* (Swainson, 1840). In both species the parapodia are edged with black outer and orange inner lines, while in *cauze* only the anterior margin of the parapodia is black.

Elysia evelinae Marcus, 1957

Figure 35

Occurrence. Biscayne Bay between Miami and Miami Beach, MacArthur Causeway, among algae, November 24, 1958, six slugs. UMML 30.1803.

Further Distribution. Coast of S. Paulo, Brazil.

Remarks. This small species, whose largest preserved animals were 3 mm long in the present material, is characterized by its greyish color, a dark nuchal band chiefly developed around the anus, and the thickened tip of the radular tooth. It has a dorsally located anal opening (Marcus, 1957: Fig. 48a) and is triaulic (Fig. 57m, q, y).

Tridachia crispata Mörch, 1863

Figs. 36-43

Elysia (Tridachia) crispata Mörch 1863, p. 40

Tridachia crispata Bergh 1872, p. 191

non *Elysia crispa* Verrill 1900, p. 547

? *Tridachia crispata* Engel 1927, p. 115

non *Tridachia crispata* Yonge and Nicholas 1940, p. 289

Occurrences. 1. Key Largo Sound, on cement pillars without macroscopic vegetation, in a depth of 0.8 m. On the bottom (1 m) marine grasses, *Padina*, and other algae. November 8, 1958, eight slugs. UML 30.1804. 2. Virgin Islands, Harbor Point, January 26, 1959, Dr. G. L. Voss leg., one slug.

Further distribution. Santo Domingo; Santa Cruz, south of Virgin Islands; Guadeloupe; Barbados; (?) Tobago; Venezuela; (?) Curaçao.

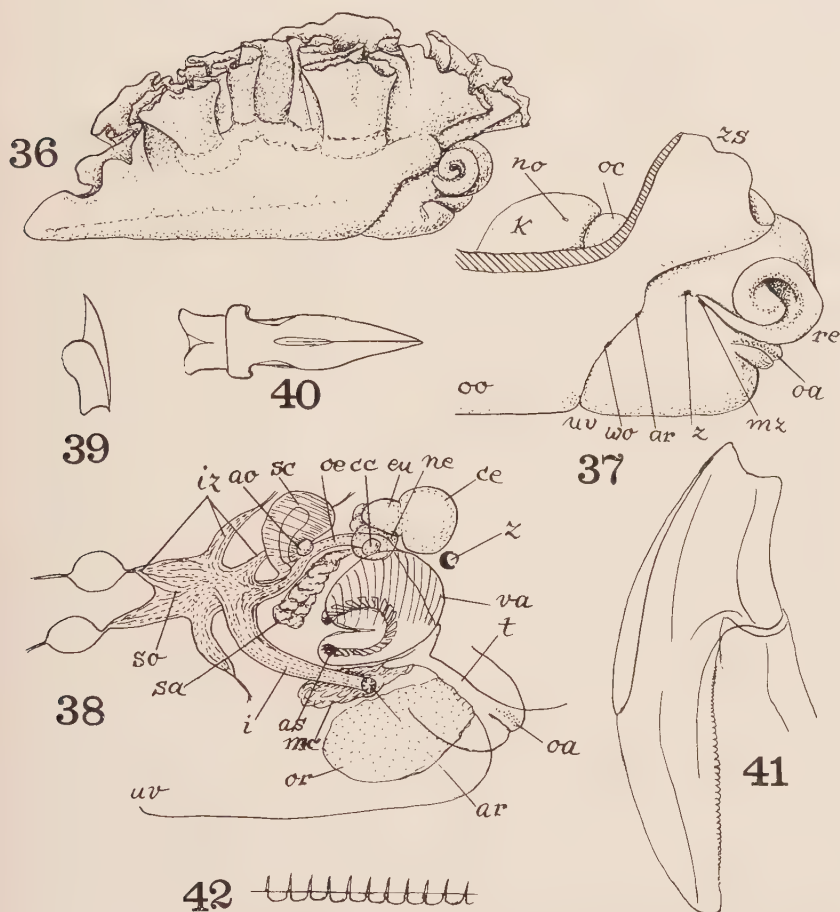
Description. The living slugs were green with white spots on the back and the parapodia. Preserved, they are cream with irregularly distributed white spots, especially numerous on the borders of the parapodia. These white spots evidently constitute the narrow white border of Bergh's description (1872: 192). Black pigment dots form a line along the transverse labial furrow, some black dots surround the black eyes, and occur on the inner side of the upper end of the involute rhinophores.

The largest preserved animal is 28 mm long and 13 mm broad, including the reflected parapodia. The rhinopores are about 3 mm long and very thick.

From the reno-pericardial eminence 2 nodulous strands or ridges run obliquely backwards, 2 outwards, and 2 forwards. These strands are vessels which shine through the skin.

The anterior fifth of the foot is separated from the rest by a more or less distinct transverse fold (uv); the sides of the foot pass gradually on to the sides of the body and the parapodia whose borders are thrown into about 5 main folds.

The foremost of the apertures of the inner organs is the male pore (mz). It lies close to the root of the right rhinophore (re) and near the eye (z). As the rhinophores are contracted, their insertion is withdrawn too, hence the male pore is hidden in a fold of the skin. The two following apertures, also dextral ones, are the anus (ar), and hindmost the single female opening (wo). Both are located in the fold that continues the anterior pedal fold towards the dorsum. Here the fold establishes the posterior limit of the head and lies in front of the anterior borders of the parapodia which are confluent in the median line. The reno-pericardial elevation is divided into a smaller anterior cardiac (oc) and a larger posterior renal (k) part by a



FIGURES 36-42. *Tridachia crispata*. FIG. 36. Right side view of preserved slug. FIG. 37. Right side view of fore end. FIG. 38. Alimentary canal reconstructed from sections. FIG. 39. Smallest radular tooth, side view. FIG. 40. Middle-sized tooth, surface view. FIG. 41. Biggest tooth, side view; same scale as 39 and 40. FIG. 42. Denticulation of biggest tooth.

sometimes unilateral fold. The nephropore (no) is situated in the posterior part a little to the right side. As MacFarland had claimed (1924: 408) we located all apertures in serial sections; they could not be seen on the surface.

The skin contains many cyanophilous glands. Between them and close to the epidermis a plexus of thin hepatic tubules spreads through the parapodia whose deeper layers lodge vessels and prostatic strands.

Many, chiefly blue staining, glands accompany the lips and folds of the head, and red staining ones surround the short mouth tube.

The nervous centers, some cells of which attain 0.15 mm in diameter, are closely united in a voluminous group surrounding the oesophagus (oe) as in *Tridachiella diomedea* (MacFarland, 1924: 410). The cerebro-pleural ganglia are fused, and also the buccal, pedal, supra- and subintestinal ganglia, and the large abdominal ganglion correspond to those in the Pacific species (Pl 12, Figs. 18, 19).

The size of the pharynx (va) also agrees with *T. diomedea* (l. c.: 408); it is 0.9 mm long and high, and 0.5 mm broad. In comparison with *Elysia cauze* whose body size equals that of our *crispata* and whose pharynx is 2 mm long, the pharynx of *crispata* is small. Also in Bergh's larger specimens of *crispata* the pharynx is no more than 1.5 mm long. The pharyngeal muscles are strong. The ducts of the salivary glands (sa) pass through the nerve collar, dilate into small ampullae and enter the pharynx close to the dorsal emergence of the oesophagus (oe). The radula contains 9 teeth in the upper, 9 in the lower limb and about 30 discarded ones in the ascus (as). The smallest tooth is 23 μ long, the largest 190 μ with a 70 μ long base. Its cusp bears rounded denticles which are largest in the middle of the row, where they are 3 μ broad. In young, 30 μ long teeth in the ascus denticles are already recognizable.

Behind the nerve ring the strongly muscular oesophagus bears a large, nearly spherical, dorsal pouch (sc), which Bergh (1872: 196) described as the stomach. Its height is 0.6 mm, the breadth 0.7 mm, and the length 0.5 mm. Its epithelium is folded. In its muscular, 0.1-0.15 mm thick wall there are scattered nerve cells connected with two ganglia (ao), the caecal ganglia of Russell (1929), located on the right and left side of the base of the oesophageal pouch, nearly as drawn by Pelseneer (1894: Pl. 19, Fig. 170). Two gastro-oesophageal nerves connect the caecal ganglia with the buccal ganglia in front and with the gastric plexus behind. Yonge and Nicholas (1940: 294) call the caecal ganglia gastroesophageal ganglia, but Hoffman (1936: 767-768) accepts Russell's argumentation (1929: 219-225).

Our specimens and those of Bergh (1872: Pl. 23, Fig. 11) have a 0.9 mm long, straight oesophagus provided with a dorsal pouch but without a loop. In *Tridachia schrammi* (see the following discussion) there is an oesophageal loop as long as the rest of the oesophagus whose entire length is 1.8 mm.

The stomach (so) has an epithelium thrown into high folds, and few muscles. It has 2 lateral diverticula, Bergh's transverse biliary duct (1872: 196), and from these diverticula emerge the hepatic ducts (iz), 2 running forwards, 2 to the sides, and 2 backwards. The intestine (i), whose lining epithelium and wall continue those of the stomach, leaves the latter in front and above. Then it curves downwards and to the right side and runs to the anus (ar) between the genital apertures. The extremely thin hepatic tubules form a much ramified plexus as in other Ascoglossa. The two posterior ducts have a widened lumen in the neighborhood of the stomach.

The heart (oc) occupies the anterior third of the reno-pericardial elevation; the strong aorta could be followed to the nerve collar. The above mentioned 6 afferent vessels communicate with the renal blood sinus. The kidney (k) is a thick-walled sac whose very thin renal duct (no) emerges from its dorsal side. As in *Elysia cauze* (Marcus, 1957: 407) the body cavity is filled with parenchymatous fibres. Contrary to *Tridachia schrammi* there are no zooxanthellae (Yonge and Nicholas, 1940: 297-300).

The follicles of the hermaphrodite gland contain mature sperms and growing ovocytes. Spermatozoa occur also in the spermoviduct. Near its origin from the latter the efferent duct receives the prostatic strands (r) which ramify through the parapodia. The efferent duct (me) dilates into a ciliated seminal vesicle (vs) in the bulb of the penis. The penial papilla distends the male atrium (ma) so that it forms a backward directed sac, to the end of which a thin-walled vesicle (xz) is connected. Similar appendages occur in *Lobiger souverbiei* (Marcus, 1957: 402) and *Elysia lobata* (*id.* 1956a: 46).

The short inner part of the oviduct is tubular and takes in the ramified albumen glands (az). From the wide, glandular, following part of the oviduct, the mucus gland (g), a long duct leads to the only existing female seminal vesicle, the spermatheca or bursa copulatrix (se) which is filled with unorientated sperm. This vesicle contains sperm, hence copulation must have been effected by means of the single female aperture, the oviducal opening (wo). Though Pelseneer said that the vagina develops late in *Elysia viridis* (1894: 62), and the female germ cells of our sectioned slugs are young, *T. crispata* must be considered as one of the numerous diallic elysiids without vaginal opening. To these *T. schrammi* also belongs (Yonge & Nicholas, 1940: 221).

Discussion. Bergh studied Mörch's animals from the neighborhood of the Virgin Islands, and ours agree with Bergh's results in the features that are essential for the name of the species: 1. absence of an orange or brown band near the edge of the parapodia and of zooxanthellae in the connective tissue responsible for this color; 2. straight oesophagus without a loop. These two characters distinguish Yonge and Nicholas' material from Bergh's and ours and require specific separation for the slugs from the Dry Tortugas. White (1952: 118) described a single specimen from the Dry Tortugas and called it *Tridachia ornata* (Pease, 1860). As Pease's Indo-Pacific *Pterogasteron ornatum*, temporarily allocated to *Tridachia* (for literature see Marcus, 1957: 416), belongs to *Elysia*, White's species had to be re-named. It was called *Tridachia whiteae* Marcus (*l. c.*). Though White did not study the oesophagus of her slug, its orange parapodial band and the locality make it certain that it is conspecific with Yonge and Nicholas' animals. According to the localities, Tobago and Curaçao, Engel's material probably belongs to *T. crispata*, but the oesophagus is not described, and a brown or orange band generally fades out in alcohol, as *e. g.* in White's specimen.

T. whiteae is evidently a synonym of *Tridachia schrammi* (Deshayes, 1857: 142). Mörch (1863: 41) had asked Deshayes whether material collected by Oersted (*crispata*) was identical with *schrammi*, and Deshayes, who knew Oersted's at that time unpublished drawings, denied it. Actually, Deshayes (p. 140) had described an orange border of the parapodia in *schrammi*, contrary to the white one in *crispata*. Pruvot-Fol (1946: 42-43), it is true, examined Deshayes' specimens, and united *crispata* with *schrammi*, but she did not consider the zooxanthellae and the oesophagus.

Possibly also some differences exist between the reproductive organs of *crispata* and *schrammi*. But the principal features of the anus and the genital apertures can be discussed in common for Bergh's and White's material, because our results in *crispata* agree with those of Yonge and Nicholas in *schrammi*. Bergh did not draw the anal opening in *Tridachia crispata* nor in the Pacific *Tridachiella diomedea*. He indicated it on the pericardial eminence (1872: 193; 1894: 194), and so it was drawn by White (1952: Fig. 19a). The sometimes unilateral fold of the eminence simulates an entry. What Bergh considered as the aperture of the mucus gland (1872: Pl. 21, Fig. 14b) was probably the anus, and the actual female pore was not seen. White (1952:

119, Fig. 18) observed 3 openings on the right side behind the rhinophore. She called them male, oviducal and vaginal aperture, perhaps influenced by MacFarland's interpretation (1924: 408) of the openings in *Tridachiella diomedea*.

Thiele (1921: 415) and Pruvot-Fol (1946: 43) give *Tridachiella* only subgeneric rank. But the mid-dorsal free space between the anterior ends of the parapodia is no longer the only character which separates *Tridachiella* from *Tridachia*. The latter has one female seminal vesicle, a spermatheca, the former two, a spermatheca and a spermatocyst (Bergh, 1894: Pl. 1, Figs. 5, 6).

Order NUDIBRANCHIA

Suborder *DORIDACEA*

Section EUDORIDACEA

Tribe *PHANEROBRANCHIATA*

Superfamily NONSUCTORIA

Family POLYCERIDAE

Polycerella conyna Marcus, 1957

Figures 44-45

Occurrence. East coast of Virginia Key, in front of The Marine Laboratory, University of Miami, among algae with Hydrozoa, the ctenophore *Vallicula multiformis* Rankin, 1956, and Bryozoa (*Bugula*, *Zoobotryon*, *Amathia*), October 27, December 19, 1958, a total of 55 slugs. UMML 30.1805.

Further distribution. Coast of S. Paulo, Brazil.

Remarks. Originally we had only two animals (1957: 429), but later found 30 more at the same locality, the Northern Basis of the Oceanographic Institute S. Paulo, near Ubatuba, where the mentioned ctenophore (du Bois-Reymond Marcus, 1956b) and Bryozoa also occur. The present preserved material contains up to 2.5 mm long slugs. Generally they have a small pair of papillae in front of the renopericardial eminence (oc) and one pair level with the gills (c) as do the Brazilian animals; behind the gills the papillae are fewer in the Floridian slugs, as only one large and only one small pair is developed.

The three species of *Polycerella* (Odhner, 1941: 15), all from the American Atlantic coast (Johnson, 1934: 157), have similar radulae. The anatomy of the type, *P. emertoni* Verrill (1881: 387), has been studied by Bergh (1883a: 137). Its spermatocyst is pear-shaped

against the spherical one of *conyna*, and the glandular or prostatic portion of its efferent duct is little more than half as long as the following ejaculatory duct, while it is nearly twice as long in *conyna*. Besides the cutaneous papillae are much more numerous in *emertoni* than in *conyna*, where there are none in front of the rhinophores (Marcus

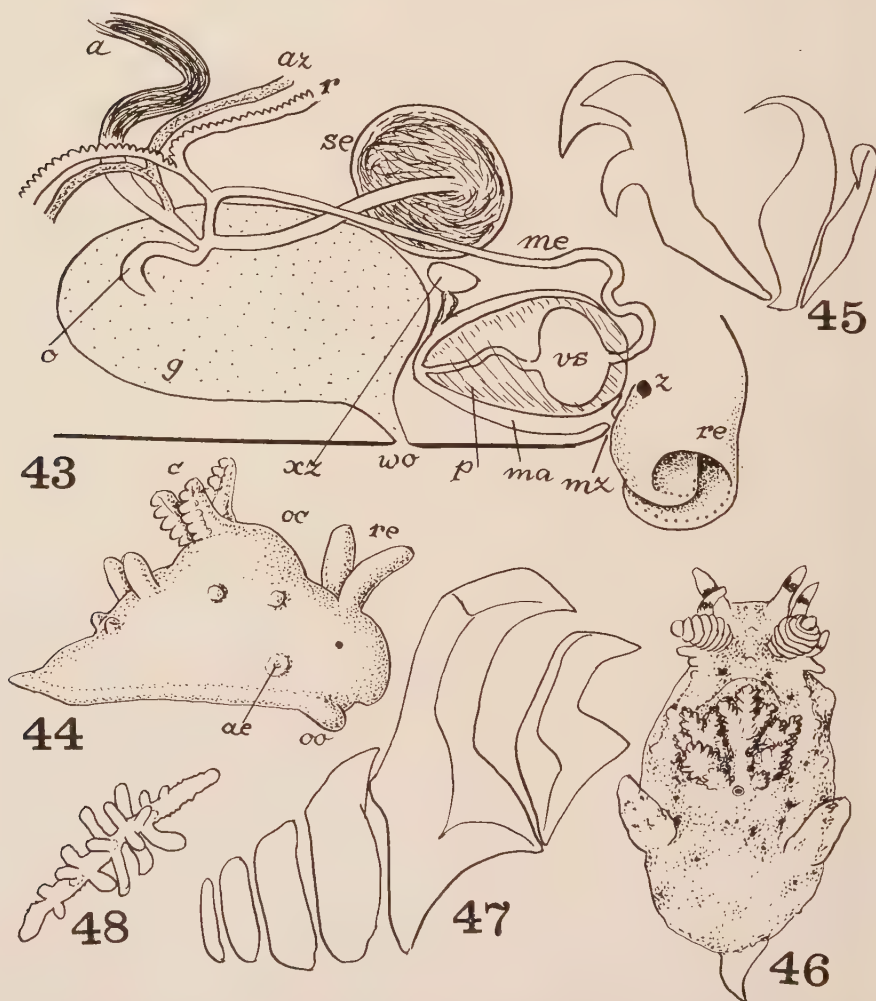


FIGURE 43. *Tridachia crispata*. Diagram of copulatory organs. FIG. 44. *Polycerella conyna*. Right side view of preserved slug. FIG. 45. Half row of radula. FIG. 46. *Polycera aurisula*. Dorsal view of preserved slug. FIG. 47. Half row of radula. FIG. 48. Spicule from parenchyma.

1957, f. 103, 104).

P. davenporti Balch (1899, p. 150) has very small marginal radular teeth, webbed gills, and peculiarly disposed notal papillae. There is one pair in front, one beside, one behind the gills, and two very small pairs forming a rosette still farther back.

Polycera aurisula Marcus, 1957

Figures 46-48

Occurrences. 1. East coast of Virginia Key, in front of The Marine Laboratory, University of Miami, December 4, 8, 1958. 2. Biscayne Bay between Miami and Miami Beach, MacArthur Causeway, November 24, 1958. A total of 20 slugs from algae. UMML 30.1806. Copulation and eggstrings laid on the marine grass seen December 8, 1958.

Further distribution. Coast of S. Paulo, Brazil.

Remarks. Our first description (Marcus, 1957: 432) rests upon five young slugs. The bright orange and blue color markings of young animals do not accompany the growth of the body, hence six adult (*id.* 1956a, published 1958: 52) appeared chiefly mottled grey as in the present specimens. In the discussions annexed to the previous descriptions we have compared *aurisula* with *P. hummi* Abbott (1952: 3-7) from the Gulf coast of Florida and from Beaufort, N. C., and separated both species. We also maintain this separation in view of the Florida material of *aurisula*.

The most striking difference is that of the gills, though we actually are doubtful about the true nature of these organs in *hummi*. According to Abbott's Figure 2 (Pl. 2) and his "Remarks" (p. 4) *P. hummi* has only one large branchial plume which is divided into several plumules. Also the description (p. 3) "the plume consists of 9 main plumules" agrees with Figure 2 and the "Remarks." A single branched gill in front of the anus, in explanation of Figure 2 "renal pore," is a quite unusual feature in *Polycera*, as Abbott was correct in noting (p. 4), and, as can be added, even in the entire Suborder Doridacea. In his additional notes (p. 7) however he indicated "the length of the largest and most anterior gill plume." This expression suggests the existence of more than one gill, and the general view (Fig. 1) is compatible with the idea of a regular polyceran branchial basket composed of several gills of different size in *P. hummi*. *P. aurisula* has up

to 9 gills, each separated from the neighboring ones down to the base. The foremost largest gills are bipinnate, the smaller ones unipinnate.

If one abstracts from the strange gills of *hummi*, possibly only described in a strange manner, there remain unquestionable differences between *hummi* and *aurisula*. The less important ones refer to the size, the number of velar processes, and the shape of the extra-branchial appendages. Living *P. hummi* is up to 20 mm long, *P. aurisula* up to 10 mm; *P. hummi* has 2 velar processes on each side, *aurisula* up to 4. The 3-4 extra-branchial appendages on either side of *hummi* are blunt club-shaped, dilated above and contracted at the base, the 2-3 conical ones of *aurisula* are carrot-shaped, pointed above and dilated near the base.

An important difference between *hummi* and *aurisula* refers to the radula. The innermost tooth and the second, the largest of the half row, are, it is true, alike in both species. For comparison with our Figure 46 "inner" and "outer" must be changed in Abbott's explanation of his Figures 6 and 7. The first marginal tooth, the innermost uncinal tooth of Abbott's terminology or simply counted the third tooth from the rhachis, has 5 small denticles on its anterior edge or cusp in *hummi*, while it is smooth in Brazilian and Floridian *aurisula*. Certainly this difference is small but incisive, as long as it does not prove to vary within the same population. Corresponding characters frequently separate species of the same genus of nudibranchs, while the color pattern may be the same or very similar, e.g. in *Phyllidia*. The reproductive organs of *hummi* which perhaps reveal further differences are not yet known.

Superfamily SUCTORIA

Family Goniodorididae

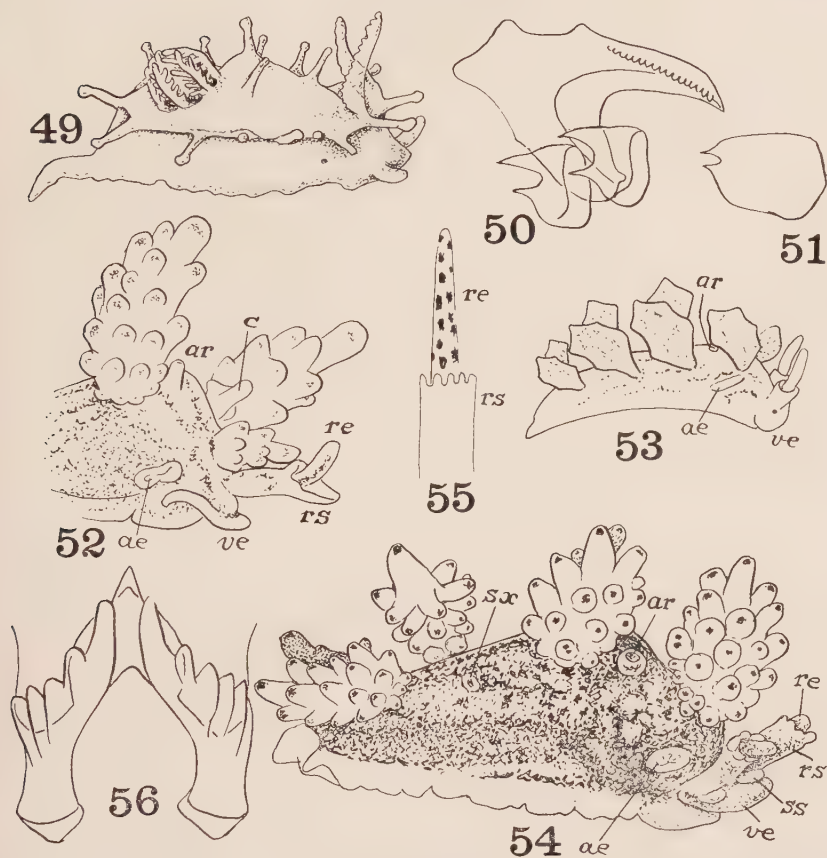
Okenia evelinae Marcus, 1957

Figures 49-51

Occurrence. East coast of Virginia Key, in front of The Marine Laboratory, University of Miami, among algae, December 4 and 8, 1958, a total of 14 slugs. UMML 30.1807. Copulation observed December 8.

Further distribution. Coast of S. Paulo, Brazil.

Remarks. Size, color, appendages, and pleurembolic male copulatory organ agree exactly with the Brazilian material (1957: 438). The gills



FIGURES 49-51. *Okenia evelinae*. FIG. 49. Right side view. FIG. 50. Lateral tooth and two successive marginal teeth. FIG. 51. Marginal tooth of another slug. FIG. 52. *Doto uva*. Right side view of fore end; first right ceras in regeneration. FIG. 53. *Doto pita*. Right side view. FIG. 54. *Doto divae*. Right side view. FIG. 55. Rhinophore of living slug, from sketch by the collector. FIG. 56. Radular tooth.

are up to 7 in number against a maximum of 6 in the examined Brazilian animals. The lengths of the lateral and marginal teeth are 80 and 30 micra against 90 and 40 in those from Brazil. The shape of the lateral tooth is the same. The points of the marginal tooth are considerably longer in some slugs from Florida (Fig. 50) than in the previously figured ones (*l.c.*, Fig. 132), but are as short as these in others (Fig. 51). The Florida material extends the range of variation of the species, but does not deserve a subspecific separation.

Order NUDIBRANCHIA
Suborder *DENDRONOTACEA*
Family DOTONIDAE

Doto uva Marcus, 1955

Figure 52

Occurrence. Key Largo, from sertularian hydroids grown on roots of mangrove, November 8, 1958, one slug and a short, slightly flattened egg string. UMML 30.1829.

Further distribution. Coast of S. Paulo, Brazil (Marcus, 1955a: 167; 1957: 455); Southern Chile, Gulf of Ancud (Marcus, 1959a).

Remarks. The present living animal was irregularly light brown, but this pigment has disappeared in the preserved specimen which has only melanophores. These occur on the club (re) and sheath (rs) of the rhinophores, on the back and sides of the body, and on the 3 upper circlets of the tubercles of the cerata. The tubercles of the fourth, ventralmost ring are in part colorless.

The length of the preserved slug is 6 mm, its height, without cerata, 1.5 mm, the cerata up to 1.8 mm high. There are 6 pairs of cerata with 4 circlets of tubercles, 6-9 in each circlet. The most striking character of the species is the beak formed by the anterior margin of the rhinophore sheath (rs). The gill (c) on the inner side of the cerata is bigger on the high middle cerata than on the first smaller ceras (Fig. 52). The specimen has the same fold of the velum (ve) produced by contraction as that of *D. chica* (see discussion of *chica*).

Doto pita Marcus, 1955

Figure 53

Occurrence. East coast of Virginia Key, in front of The Marine Laboratory, University of Miami, among algae, December 4, 1958, one slug. UMML 30.1821.

Further distribution. Coast of S. Paulo, Brazil.

The preserved animal is 2 mm long, has some brown spots on the back and 4 pairs of cerata. As in the original material gills are not distinguishable, and the small scattered tubercles of the preserved specimen are still less salient than in the living slug (Marcus, 1955a, Fig. 223 A, B). The recently described reproductive organs (Marcus, 1957: 455) were not examined in the present animal, in order to keep it whole for the Miami collection.

Doto divae, spec. nov.

Figures 54-57

Occurrence. East coast of Virginia Key, among the growth on the constantly submerged panels hanging down from the pier of The Marine Laboratory, University of Miami, December 19, 1958 and January 9, 1959, four slugs. UMML 30.1808.

Description. The preserved animals are 3-6 mm long, and in all four the tip of the hind end was bitten off. They are up to 2 mm high without cerata and 1.8 mm broad. The length of the cerata attains 1.8 mm. As annotated by the collector, the ground color of the living slugs was yellowish white with red cerata in 2 specimens. Black pigment occurs on the tips of the tubercles, the rhinophores, specially their clubs (Fig. 55, re), the back and the sides of the body. The black pigment is preserved after fixation, but the yellow and red tones have vanished as nearly always in alcohol. The color of the hepatic diverticula in the cerata is conditioned by the food and taxonomically without weight (Pruvot-Fol, 1954: 406).

The veil (ve) is broader than long, well rounded. The margins of the rhinophorial sheaths (rs) are jagged with about 8 equal points. There is a boss (ss) on the veil in front of each rhinophore. The anterior border of the foot is bilabiate.

The number of the cerata, 5 pairs in the larger, 4 in the smaller slugs, may be incomplete, as the hind end of the body is mutilated. The cerata are tipped by a strong tubercle; the quincuncial, not serial, about 30 tubercles on their sides diminish towards the base of the ceras. Their black terminal spot lies immediately under the thin epidermis and the cutaneous muscles, hence it appears quite intense, darker than in *D. uva*. The big subepidermal so-called defensive glands in the cerata of other species are absent. The gills are small, developed approximately to the same degree as the most distinct gill seen in *D. chica* (Fig. 59, c). In correspondence with the inconspicuous gills the inner sphincter at the root of the ceras (Marcus, 1957: 458) is weak, while the outer one and that of the diverticulum of the intestinal gland are well developed.

The masticatory process of the jaw is smooth as in other species of the genus (Marcus, 1955a: 168). The radula comprises 86 teeth with strong lateral denticles on either side of the median cusp. The left posterior gland of the oral tube is considerably larger than the right

one (Hoffman, 1938: 922-23, Fig. 639 A, B). The genital aperture (ae) is located ventrally to the first right ceras, the stellate anus (ar) farther dorsally on a globose papilla between the first and second right ceras. The renal pore lies immediately behind the anus and closes in front of the renopericardial communication.

The hermaphroditic gland is rather compact and peripherally contains the female, centrally the male germ cells. The spermovi duct is much shorter than in *D. uva* (Marcus, 1959a: Fig. 160). The male organs are similar to those of that species. They differ by a narrow portion between the origin of the male branch and the beginning of the prostatic part (r), and a much longer distal male duct (me). The female organs are more peculiar. The so-called bursa of *D. uva* is absent, perhaps represented by a gland (zc), and the aperture of the vagina (v) is separated from that of the nidamental duct (n). The antero-posterior sequence, opening (mz) of the male atrium (ma), vaginal opening with sphincter (x), and oviducal aperture (wo) is the same as in *D. pita* (Marcus, 1957: Fig. 175), and like that species *D. divae* is triaualic.

The species is named for the collector, Dr. Diva Diniz Corrêa.

Holotype. A series of transverse sections, two slides, UMML 30.1809.

Discussion. In Odhner's key to the valid species of *Doto* (1936: 1119-21) *D. divae* fits into Group I, Subgroup B, according to the black apical spots of the tubercles and the number of cerata. But as the cerata neither are globose and provided with 4 rows of tubercles (I B 1), nor the tubercles indistinct and disposed in 2-3 row (I B 2), *D. divae* cannot be identified with one of the species of Subgroup I B. After our experience with *D. uva*, described with 5 pairs of cerata (Marcus, 1955a: 168) and later on found with 7 and 8 pairs (*id.* 1957: 455), we compare *D. divae* also with Odhner's Subgroup I A. All species in this subgroup can easily be separated from *divae* by their color, or a prolonged anterior margin of the rhinophorial sheath, with exception of *D. pinnatifida* (Montagu, 1804). Typical *pinnatifida* as figured by Alder and Hancock (1855: Fam. 3, Plate 3, Supplementary) has a row of small papillary tubercles extending down each side to the tail, but Eliot (1910: 124) has described varieties of *pinnatifida* having these tubercles "indistinct" or "not well developed." Especially *pinnatifida* var. *nigra* with the margin of the rhinophorial sheath "deeply jagged" deserves attention. Its "clear bright yellow rhinophores contrasting vividly with their dark sheaths" are however

incompatible with *divae*, and still more important is the "large and elaborate gill" of *pinnatifida* (Odhner, 1936: 1117).

Among the species with dark tipped tubercles described after the publication of Odhner's key *D. purpurea* Baba (1949: 172) and *D. uva* Marcus (1955a: 167) have digitiform or beak-like processes respectively on the margin of their rhinophorial sheaths. In *D. bella* Baba (1938: 132) this margin is smooth. The last species has 7 pairs of cerata, each with 4 circlets of sparsely set globose tubercles; its body has no melanophores.

Doto chica, spec. nov.

Figures 58-60

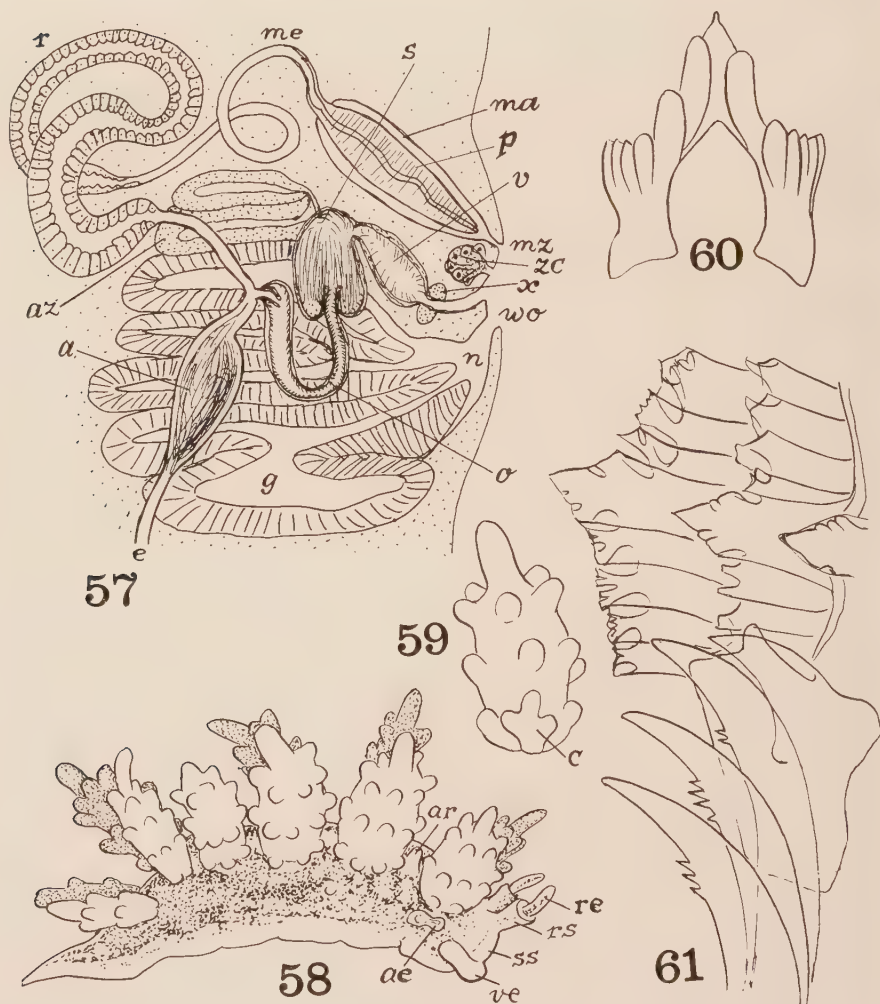
Occurrence. East coast of Virginia Key in front of The Marine Laboratory, University of Miami, among algae, December 8, 1958, one slug.

Description. The preserved animal is 4.5 mm long, 0.9 mm high without cerata, and 0.8 mm broad. The cerata are up to 1.2 mm high. Some blackish pigment occurs on the back, the sides, and the rhinophorial sheaths (rs) and clubs (re). The general color is whitish, but no indication concerning the living animal is available. The tips of the tubercles appear especially light.

The veil is somewhat contracted (ve), and its margin set off. There are two longitudinal ridges (ss) extending from the rhinophores forwards. The margin of the rhinophorial sheaths is smooth. The right side of the body bears one, the left two tubercles which recall the series of tubercles in *D. pinnatifida* (see discussion of *D. divae*). The anterior pedal border is bilabiate, the tail pointed and about as long as the sixth cerata.

There are 6 pairs of cerata and a bud of a seventh ceras on the left side. The two fifth cerata are grown together, evidently malformed. The uppermost tubercle of each ceras is elongated; the following tubercles form up to 4 circlets with a maximum of 8 tubercles each. All tubercles have rounded ends, though preserved material is not sufficient for a definitive description of the tips of the tubercles. The gills are small, but recognizable as transparent knobs on the inner basal side of the large cerata. Only on the third left ceras 3 coalesced knobs form the gill (c).

The radula contains about 60 teeth. The greater or smaller distance



FIGURES: 57. *Doto divae*. Diagram of reproductive organs. FIG. 58. *Doto chica*. Right side view. FIG. 59. Third left ceras seen from inner side. FIG. 60. Radular tooth. FIG. 61. *Armina mülleri*. Two median radular plates and first to fourth lateral plates.

between the median cusp and the neighboring right and left lateral denticle respectively alternates in the succeeding radular teeth. A similar alternation was described for the radula of *D. uva* (Marcus, 1959a). The wide genital aperture (ae) lies ventrally to the first right

ceras, the anus (ar) on a papilla between first and second right ceras.

Holotype. A slide with the radula, and the slug without it, UMML 30.-1810.

Discussion. As the tips of the tubercles are a little lighter than the general color, the species must be compared first with those of Odhner's Group II (1936: 1120). All species of uniform color, without spots (II A) can be excluded. *D. rosea* and *D. cinerea* with darker spots have a black spots at the base of each ceras, distinctly figured on the original plate (Trinchese, 1881: Pl. 55), a constant character (Pruvot-Fol, 1954: 406). Pruvot-Fol unites *cinerea* with *rosea*. The lateral denticles of the radular tooth of *cinerea* are inconspicuous (Vayssi re, 1888: Pl. 7, Fig. 136), while those of *chica* are much stronger.

The tubercles on the cerata of *Doto* are known to be extensible. Therefore *D. chica* must be compared also with Odhner's Group III which includes the species with elongate and pointed tubercles. Of these *D. fragilis* (Forbes, 1838) differs by the greater number of cerata and circlets of tubercles, and many more radular teeth. The last character, branched gills, and lobed rhinophore sheaths distinguish *D. apiculata* Odhner, 1936, from *chica*; both species have elongated tops of the cerata. In the Subgroup III B 2 with indistinct gills only *D. cornaliae* Trinchese (1881: 91, Pl. 54) has the smooth borders of the rhinophore sheaths like *chica*. But *cornaliae* has no black color elements at all and distinctly pointed elongate tubercles.

D. rosacea Baba (1949: 172) and *D. albida* Baba (1955: 50) are also without melanophores: the first has lobated margins of the rhinophore sheaths and less tubercles than *chica*, the second globose tubercles. The tubercles of *D. caramella* Marcus (1957: 458) are small and cuspidate, the base of each ceras is black, and the rhinophorial clubs are without pigment.

In the Florida specimen of *D. uva* (Fig. 52) and that of *chica* the margin of the velum is set off by a furrow due to contraction. Thus a certain resemblance arises with the "tentacles" of *Heromorpha antillensis* Bergh (1874b: 610). Of the latter only one ceras of the hindmost pair is known, and the absence of tubercles on it has little systematic value (Odhner, 1936: 1118, note 2). Bergh's drawings of the rhinophorial sheath (Pl. 8, Fig. 12, 14) of *antillensis* do not agree sufficiently with *uva* or *chica* to allow for an identification of one of these with *antillensis*.

Order NUDIBRANCHIA

Suborder ARMINACEA

Tribe EUARMINACEA

Family ARMINIDAE

Armina mülleri (v. Ihering, 1886)

Figures 61-67

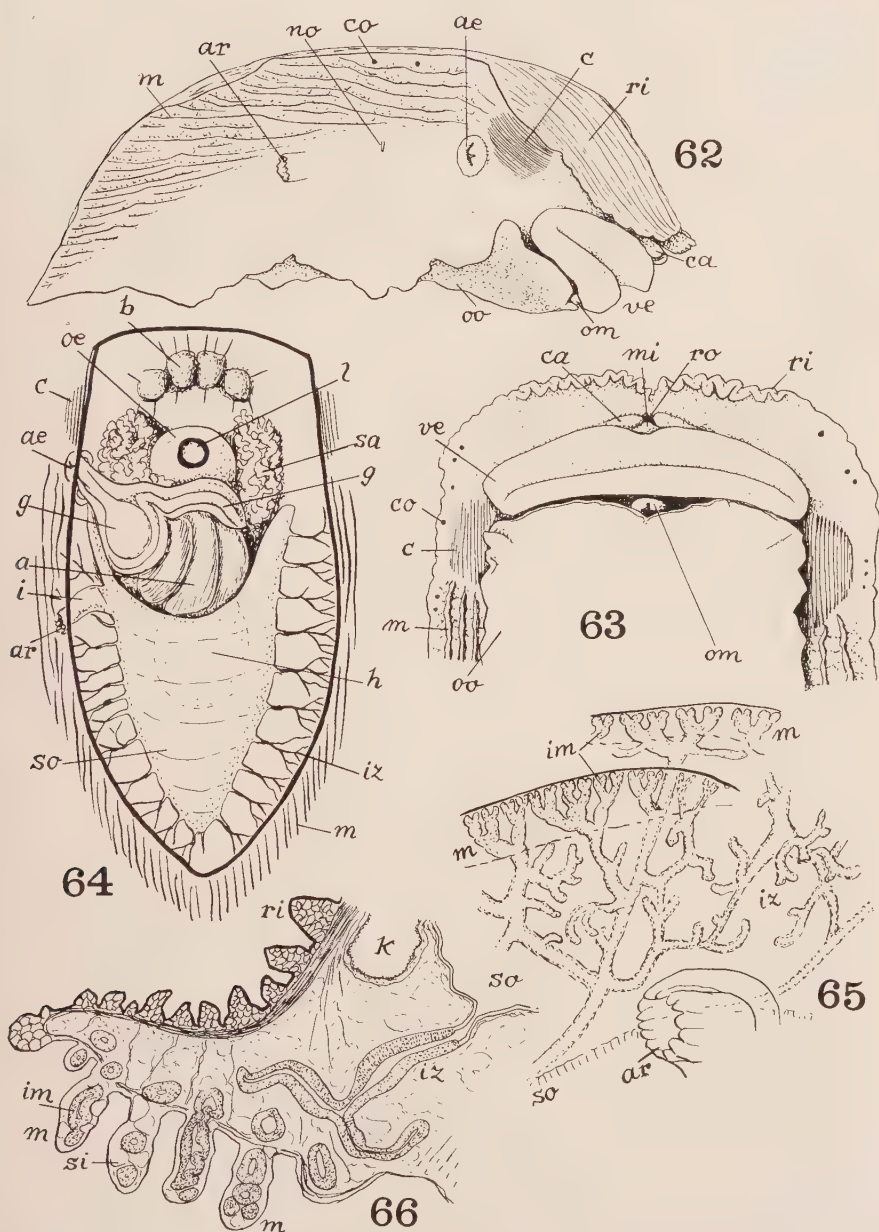
Occurrence. Near Cabo Frio (Lat. 22°57'S. Long. 42°1'W.), in the beginning of June, 1958, Lic. L. Tommasi leg. one slug.

Further distribution. South Brazil, coast of Sta. Catharina, two specimens collected by Fritz Müller (v. Ihering 1886, p. 223; 1915, p. 143).

Description. The preserved slug is 16 mm long, 7 mm high, and has an 11 mm broad notum. The foot is 13 mm long and 8 mm broad. The animal is opaque and uncolored, and so it was alive, according to the collector's information. The furrows between the notal ridges (ri) are a little darker than the rest, but not the sole. The breadth of the 35-40 ridges varies; especially the marginal ones are narrower, and not all begin quite in front. About 6 of the outermost ridges bend to the margin, where they end in front of the middle; in the second third of the body there are about 20. The notum projects over the neck and ends with a rather straight border frilled by the ridges and rounded at the corners. Behind these about six pores (co) of marginal glandular sacs, the cnidophores of Bergh, lie on each side on the underside of the mantle. The hind end of the notum is pointed.

The concave sides of the body bear a roundish group of branchiae (c), each with 22-25 very thin leaves. From these 2-3 lateral lamellae (m) start, increasing backwards to a total of about 25. All are rather parallel to the long axis of the body, but as the margins slant to the pointed hind end, the posterior lamellae form an acute angle with the notal border. In this hinder part some short lamellae occur between longer ones.

The semilunar frontal veil (ve) is as broad as the foot (oo), its upper margin is thin, the under margin thick. The neck is smooth, without papillae, but bears two swellings, Bergh's caruncles (ca), in front of the rhinophorial pocket (ro). A small median boss (mi) lies between the caruncles. The rhinophores are completely withdrawn and were examined by opening the pocket. They have about 25 leaves disposed almost parallel to the main axis of the club. The anterior



FIGURES 62-66. *Armina mülleri*. FIG. 62. Right side view of preserved slug. FIG. 63. Ventral view of fore end. FIG. 64. Ventral view after removing the foot. FIG. 65. Ramifications of digestive gland. FIG. 66. Transverse section of mantle border.

edge of the foot is slightly notched and illusively grooved; the furrow of the posterior pedal gland is 5 mm long. A split lip (om) hangs over the mouth. The single aperture (ae) of the reproductive organs opens under the right group of gills (c). The anal papilla (ar) which is dilated by fecal matter in our specimen lies a little behind the middle of the body. The renal pore (no) is situated between anus and gonopore.

The notal ridges (ri) are coated with a high epidermis whose numerous glands are sunk into the subjacent connective tissue. Epidermal spicules were not observed. The connective tissue of spongy structure contains many blood lacunae. Below it the cutaneous musculature forms a thick even layer. The muscles of the lateral lamellae are weak and their epidermis is thin. They contain blood lacunae (si) and liver branches (im). Also the skin is thin on the sides of the body.

The hind end of the 4 mm long pharyngeal bulb is surrounded by the paired, pink-staining salivary glands (sa). They form a rather compact mass of small lobes. The jaws have 4 rows of denticles on the masticatory process. The radula (Fig. 61) contains 44 rows of plates with the formula 50.1.1.1.50, or less. The median plate is 0.25 mm broad and has 3-4 denticles on either side. These are carved in younger and smoothened by wear in older plates. The innermost lateral or intermediate plate is massy. Exceptionally it has a vestigial outer denticle. The 20-30 following lateral plates show, when in favorable position, 1-4 denticles far behind the cusp. The 30-20 outer lateral plates are smooth; the outermost are smaller than the others.

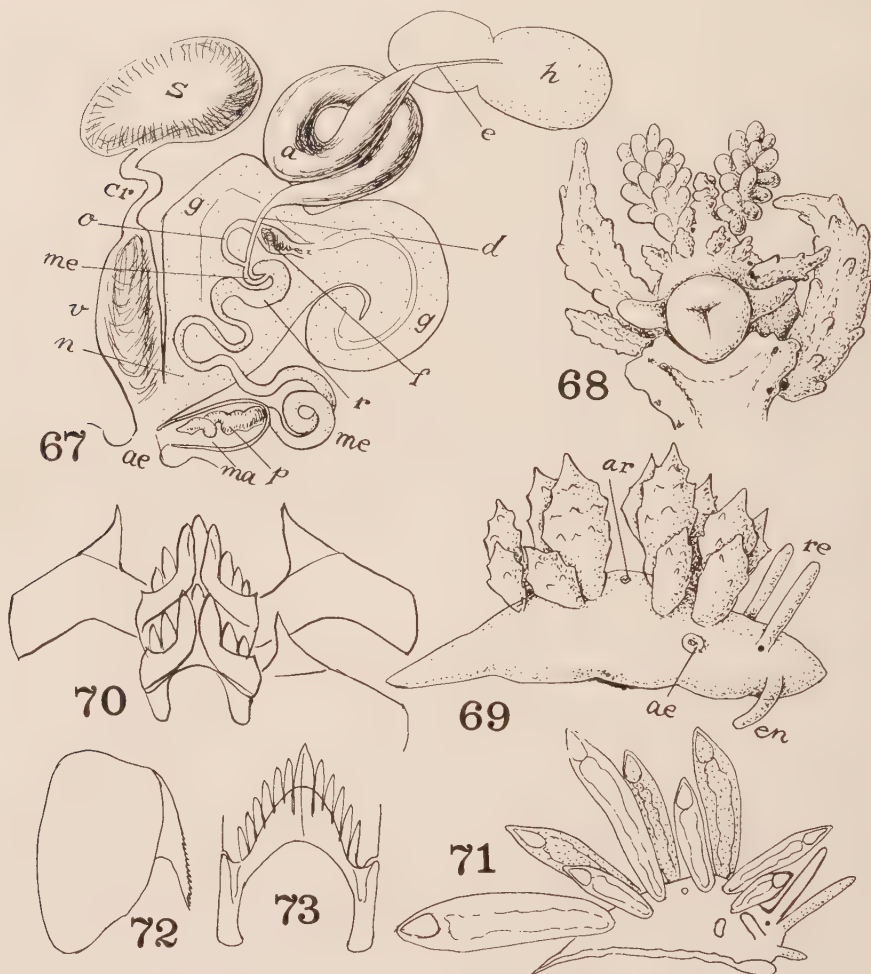
The dorsal channel of the pharynx is continued into a wide and short oesophagus (oe) which immediately dilates into the broad flat stomach (so). The stomach is thin-walled and extends nearly to the hind end where it ends pointed. The epithelium of the stomach is thrown into transverse folds. The right anterior and the left anterior livers begin broader than the diverticula of the left posterior liver, about 10 on either side. The high yellow epithelium of the hepatic branches contrasts with the colorless cylindrical and ciliated gastric epithelium which enters for a short extent into the hepatic ducts.

The diverticula of the digestive gland (Figs. 65, 66) spread through the parenchyma (iz) anastomizing now and then. Where the branches cross a lateral lamella, a twig enters it and dichotomizes 3-4 times (im), so that the lateral lamellae are richly supplied with hepatic branches.

The short intestine (i) leaves the stomach (so) antero-ventrally and curves to the anus (ar). The alimentary canal contains principally violet spicules and pieces of flesh of sea pansies (*Renilla*). This agrees with observations on arminids from California and the Gulf of Mexico (Hedgpeth, 1953: 159). Further contents of the alimentary canal were: many disc-like diatoms, a big foraminifer, a crustacean, probably a young cirriped, and a small lamellibranch.

The postero-dorsal hermaphrodite gland (h) consists of two lobes between which the hermaphrodite duct (e) begins. It dilates into the sausage-shaped glossy ampulla (a) curled around itself. The ampulla ends at the left or inner surface of the female gland mass (g), a broad band whose several coils are rolled up in a direction contrary to that of the ampulla. The albumen gland lies on the right or outer side of the gland mass. The spermoviduct divides into a short oviduct (o) which enters the mucus gland and a long spermiduct, entally prostatic (r), ectally muscular (me). The spermiduct runs twisted forwards over the gland mass and enters the penis (p). The latter fills the male atrium (ma) completely and terminates with an arrow-shaped point without cuticle. The female ducts, the wide external oviduct or nidamental duct (n), and the strongly muscular vagina (v), are separated except for a short outermost portion. In copulation the vagina receives the sperms by which it is dilated in the present specimen. The vagina is continuous with a narrow canal (cr) which leads to the seminal receptacle (s). This reservoir has no direct communication with the oviduct. Hence, for fertilization, the spermatozoa must descend the canal of the receptaculum and the vagina, enter the nidamental duct, rise through the female gland mass and reach the inner oviduct (o). Here they are accumulated so that the inner oviduct functions as a fertilization chamber (f).

Discussion. Our specimen is half the length of the two animals of the first description (Ihering, 1886: 224). As there are other, more important disagreements, our classification must be justified. Ihering's slugs had a dark, nearly black, notum with light yellow or pale reddish ridges. Also other parts of the body were more pigmented in the original material than in the present one. Bergh (1894: 155) mentioned comparable differences in the color of individuals belonging to one and the same species of *Armina*. Moreover Eales (1938: 113) observed that the original color had largely disappeared in many of her specimens of *A. semperi*. The direction of the lateral lamellae



FIGURES 67-68. *Armina mülleri*. FIG. 67. Diagram of reproductive organs seen from inner side; female gland mass unrolled. *Janolus comis*. FIG. 68. Preserved slug seen from front. FIG. 69. *Capellinia concicla*. Right side view of living slug from a sketch by the collector. FIG. 70. Radular teeth. FIG. 71. *Catriona tina*. Right side view of preserved slug; appendages of left side stippled. FIG. 72. Jaw. FIG. 73. Radular tooth.

varies according to the contraction of the body (Bergh, *l.c.*). Therefore the divergence between Ihering's (p. 225) and our material has no significance. The most serious objection against our classification may

perhaps arise with regard to the denticles of the lateral radular plates. Ihering (p. 226) called them all smooth, not denticulated. It seems, however, that in species of *Armina* with a scarce denticulation restricted to the inner lateral plates the denticles may be altogether absent. *A. semperi* was originally described as provided with denticles on 7-8 inner lateral plates (Bergh, 1874a: 250), whilst Baba (1955: 48) found all plates smooth in most of his specimens. Hence the difference of Ihering's and our radula probably has no taxonomic weight.

We have compared our slug with the descriptions of the species of *Armina* recorded from South and West Africa, the Atlantic Ocean and the Mediterranean Sea, adopting, for the latter, Pruvot-Fol's synonymies (1937: 56-64; 1954: 342-346). Of these, *maculata* Rafinesque, 1814, has a nodulose notum. All the following species with notal ridges differ from *A. mülleri* by the rhachidian plate of the radula or by the denticulation of the lateral plates, viz. *capensis* (Bergh, 1907), *euchroa* (Bergh, 1907), *gilchristi* (Bergh, 1907), *grisea* O'Donoghue 1929, *henneguyi* (Labbé, 1922; probably a synonym of *lovéni*), *liouvillei* Pruvot-Fol, 1953, *lovéni* (Bergh, 1860), *microdonta* (Bergh, 1907), *natalensis* (Bergh, 1866), *neapolitana* (Delle Chiaje, 1824), *serrata* O'Donoghue, 1929, and *tigrina* Rafinesque, 1814.

The sperm-storing vesicle was called the seminal vesicle (Bergh, 1907), spermatheca and spermatotheca (Bergh, 1874a; 1894; Pruvot-Fol, 1937; Eales, 1938; Risbec, 1956) or bursa copulatrix (Vayssiére, 1901; Misuri, 1917). As the sperms lie orientated with their heads attached to the wall of the vesicle (s) it should be called seminal receptacle (receptaculum seminis) or spermatocyst. Hoffmann (1940: 78) questioned Pruvot-Fol's observation (1937: 61) of liver diverticula in the branchial leaves. In the present specimen the branches of the digestive gland do not enter the gills. On the other hand, all researchers of arminids, Bergh, Vayssiére, Misuri, Pruvot-Fol, agree upon the extension of hepatic branches into the lateral lamellae, while Eales' figure (1938, text-fig. 25) and text (p. 115) is not quite explicit in this respect. Another point of her description referring to the single pair of salivary glands touches an old open question in *Armina* (Pruvot-Fol, 1937: 60-61; Hoffman, 1938: 924). Evidently the long and delicately branched salivary glands of Eales' slug correspond to the "Nebenspeicheldrüsen" of Bergh (1904: 23) and are what Hoffmann (*l.c.*) called posterior glands of the oral tube, "hintere

Mundröhrendrüsen." Eales did not describe the rather compact glands found by other observers opening into the pharyngeal cavity which also occur in *A. mülleri* (Fig. 64, sa).

Suborder *ARMINACEA*

Tribe *PACHYGNATHA*

Family *Antiopellidae*

Janolus comis Marcus, 1955

Figure 68

Occurrence. East coast of Virginia Key, in front of The Marine Laboratory, University of Miami, among algae, December 4, 1958, one slug. UMML 30.1828.

Further distribution. Coast of S. Paulo, Brazil (Marcus, 1955a: 170; 1958a: 32).

Remarks. The preserved 2 mm long animal agrees with the Brazilian specimens in all external characters, so that it could be kept for the Miami collection without dissection. Also Dr. Corrêa's notes concerning the color and the cerata of the living slug correspond to the original description. In order to facilitate determination we give the frontal view of the present animal, completed by one from Brazil, because the muzzle of the Floridian slug was bitten off.

Suborder *EOLIDACEA*

Tribe *ACLEIOPROCTA*

Family *EUBRANCHIDAE*

Capellinia conicla Marcus, 1958

Figures 69-70

Occurrence. 1. East coast of Virginia Key, among the growth on the constantly submerged panels hanging down from the pier of The Marine Laboratory, University of Miami, October 29, 1958, and among algae in front of the laboratory, December 8, 1958. 2. Biscayne Bay between Miami and Miami Beach, MacArthur Causeway, among algae, November 24, 1958. A total of 12 slugs. UMML 30.1811.

Further distribution. Coast of S. Paulo, Brazil.

Remarks. Most of the animals were taken on those panels immersed in somewhat deeper water (0.5-3 m). The living slugs were up to 3 mm

long, pinkish white and mottled with brown. The collector's notes stress the hugeness of the cerata. These are disposed in 4-5 groups, are knobbed and caducous, as the scars of those that have fallen off prove. The biggest preserved slug is 2.4 mm long, and its largest cerata are more than 1 mm high. We examined the jaws and the triseriate radula, and compared the long glands of the oral tube, the obliquely cut stylet of the penis, and the topography of the reproductive organs (Marcus, 1958a: Fig. 80) in sections to make sure of the determination.

Family CUTHONIDAE

Subfamily Cuthoninae

Catriona tina Marcus, 1957

Figures 71-73

Occurrence. East coast of Virginia Key, among the growth on the constantly submerged panels hanging down from the pier of The Marine Laboratory, University of Miami, October 29, 1958, one slug. UMML 30.1813.

Further distribution. Coast of S. Paulo, Brazil.

Remarks. The preserved white animal is little more than 1 mm long and has up to 1 mm long cerata. These stand in 4 groups with 2, 1, 2, and 1 cerata on the right and 2, 2, 2, and 2 on the left side. The jaws with fine pointed teeth on the masticatory process, the horseshoe-shaped radular teeth with their very deep hinge grooves, and the truncated tubular penial stylet agree perfectly with the corresponding organs of the Brazilian specimens (Marcus, 1957: 459).

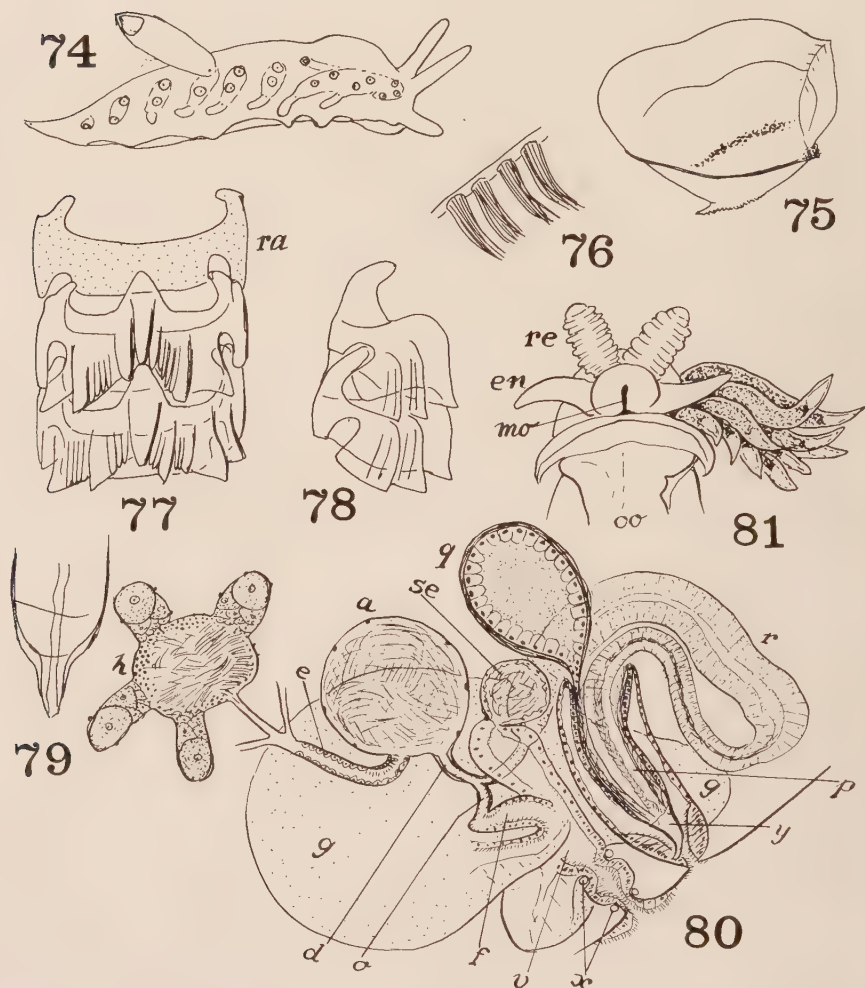
Catriona maua, spec. nov.

Figures 74-79

Occurrence. East side of Virginia Key, among Hydrozoa from the fence around the pier of The Marine Laboratory. University of Miami, December 5, 1958, two slugs. UMML 30.1812.

Description. The preserved animals are 5 mm long, and about 1.5 mm broad and high, without the cerata which are up to 1.7 mm long. The living slugs were white with a little brown, probably in the digestive gland. The eyes are black.

The head is narrow as in other species of the genus. The tentacles are short (0.6 mm) and directed to the sides; the smooth rhinophores are 1 mm long. The anterior angles of the foot are rounded; the foot



FIGURES 74-79. *Catrina maua*. FIG. 74. Right side view of preserved slug; most cerata removed. FIG. 75. Jaw. FIG. 76. Bristly teeth of masticatory border of jaw. FIG. 77. Radular teeth. FIG. 78. Side view of same. FIG. 79. Penial stylet. FIG. 80. *Tenellia pallida*. Reproductive organs. FIG. 81. *Learchis poica*. Ventral view of fore end.

is not quite as broad as the body, and the tail is pointed. The cerata are generally widest above the middle; the cnidosacs 0.1-0.3 mm long. The cerata stand in simple rows on cushions, the 3 rows of the right liver on one cushion together. Each of these rows contains 3 cerata.

The posterior liver comprises 6 rows, the four anterior ones with 3 cerata each, the two last with 2 and 1.

The genital apertures lie close together ventrally between the first and second right row of cerata. The smaller male pore is in front of and farther ventral than the female opening. The anus is dorsal to the first row of the right posterior liver.

The labial disc is broad, its passage a little wider ($75\ \mu$) than the radula. The jaw is transparent with an oblique streak of black granules (Fig. 75) and with a sculptured boss on the outer surface in the region of the hinge. The broad masticatory borders of the mandibles are coalesced behind. Their denticles are about $15\ \mu$ long, consist of about 20 fine bristles each, and are extended only over the hind part of the process. The radula contains 80 teeth including the complete pre-radula. The oldest teeth are much higher and narrower than the following ones; the first tooth is tricuspidate. The measurements of the teeth are in micra: 1st 33 high, 8 broad; 7th 4 high, 10 broad; 22nd 6 high, 12 broad. The largest teeth (60th-80th) are 20 high, 60 broad. The hinge grooves are very deep, and the hinge teeth bent inwards. The basal plate (ra) of the tooth forms a broad U. The cutting edge comprises a median and several lateral cusps. The median cusp lies high over the radular membrane; it is receded from the cutting edge and advanced over the opposite edge. The 2-4 lateral cusps on either side advance over the cutting edge and are different in size and position, producing slanting convergent rows along the radula. The inner surface of the principal lateral cusps is subdivided by 2-4 lesser denticles.

The diverticula of the digestive gland in the cerata have a nearly smooth surface. The penis papilla is armed with a $50\ \mu$ long, weakly cuticularized stylet. A penial gland is present as in other cuthonids.

Holotype. The complete slug, UMML 30.1823.

Discussion. *C. aurantia* (Alder and Hancock, 1842: 34; 1851, Fam. 3, Pl. 27), the type of the genus (Wincksworth, 1941: 148), *C. gymnota* (Couthouy, 1839: 69; Gould, 1870: 249) more fully described by Bergh (1886a: 31), and *C. columbiana* (O'Donoghue, 1922: 160), all with much receded median cusp of the radular tooth, are related to the present species. In *C. aurantia* the right liver comprises 4 rows (Odhner, 1939: 70) against 3 in *maua*. In *C. gymnota* this liver has 3 rows; our indication of 5 rows (Marcus, 1958a: 50) was incorrect. The right liver of *C. columbiana* is not described. This last

species has secondary cusps or denticles ("tiny spines") between the median and the primary lateral cusps. Its elongated oval jaw with a longer masticatory process than in *maua*, the extremely long cerata (height of body 1.25, of cerata 3 mm), and, less important, wrinkles in the two upper thirds of the rhinophores distinguish *columbiana* from *maua*.

The rhinophores of *gymnota* are shorter than the tentacles, and there are more, up to 7, cerata in the first rows of the posterior liver. The anus lies behind the level of the second row of the posterior liver. Also the round, only 2 μ long denticles of the mandibular border (Bergh, 1886: Pl. 4, Fig. 13) differ from those of *maua*. Bergh did not mention a penial stylet in *gymnota*, but it can be supposed to be present.

Eolis concinna Alder and Hancock (1843: 234; 1845, Fam. 3, Pl. 24) cannot be compared with *gymnota* (Bergh, 1886a: 31, note 1; 1892: 1023), because the median cusp of its radular tooth projects beyond the cutting edge (Alder and Hancock, 1855: Pl. 47, suppl., Fig. 19; Eliot, 1906: Pl. 366, note). *E. concinna* belongs to the genus *Cuthona* Alder and Hancock (1855: XXII) (see Odhner, 1939: 70). Verrill (1881: 390) was right to state the relation of *gymnota* with *aurantia*.

Subfamily Tergipedinae

Tenellia pallida (Alder and Hancock, 1855)

Figure 80

Occurrence. Cananéia, 200 km SW of Santos in brackish water of highly variable salinity (14-26.3 per mil) among Hydrozoa, IV.-VII. 1953, VII. 1958, a total of 35 slugs.

Further distribution. European Atlantic and Baltic coasts from the Lofoten Islands eastwards to Finland, southwards to Great Britain and France (Caen, Arcachon). Mediterranean Sea: Gulf of Naples, Marseille, Banyuls-sur-Mer.

We received specimens of the material described as *Embletonia mediterranea* by Vannucci and Hosoe (1953) for examination of the reproductive organs and also collected further slugs at their locality. The classification was established by comparison with the principal descriptions and figures of *Tenellia pallida* (Alder and Hancock, 1855: 52; appendix, p. XII), by Meyer and Möbius (1865: 17),

Eliot (1910: 128), Löyning (1927: 65) and ourselves (Marcus, 1955b: 238: material from the Mediterranean Sea).

As Vannucci and Hosoe noted (p. 108), the slugs are small. Hosoe's drawings of living animals (Pls. 4 and 5) show the rhinophores rather distant from one another, and we saw them so in the living slugs too. This contrasts with what is common in *pallida* (e.g. Odhner, 1907: 30). In preserved animals the rhinophores are much more approached due to contraction of the veil. The corners of the latter may be rounded and inconspicuous or more produced as if provided with quite small knobs, perhaps vestigian tentacles. Further variable characters are the size and number of the dark stellate chromatophores, the length of the cerata and the smooth or slightly knobbed hepatic diverticula.

The systematically important characters, radula and reproductive organs examined in 8 series of sections, agree perfectly, as do the preradular plate (Marcus, 1955b: Fig. 28). The tip of the penis (p) bears a curved cuticular stylet (y), contrary to Vannucci and Hosoe's statement (1953: 106). Dense cilia occur in the hermaphrodite duct (e) near its entrance into the ampulla (a) as in our material from Banyuls-sur-Mer. The latter and the present slugs have no sorting structure in the 50 μ long narrow ental oviduct (o), where Chambers (1934: 621) found the hermaphroditic valve in *T. fuscata* (Gould). This species and our *pallida* from Banyuls-sur-Mer as well as the present slugs have a glandular organ (q) coated with muscles opening into the spongy connective tissue at the root of the penis. The length of this organ varies due to different stages of contraction, hence does not imply a specific character.

Discussion. We follow Pruvot-Fol (1954: 410) and restrict the genus *Embletonia* Alder and Hancock, 1851, to species that, as the type *E. pulchra* (Alder and Hancock, 1844: 329), have one ceras to each group and do not possess true cnidosacs in pervious communication with the hepatic diverticula. These species are *E. faurei* Labbé (1923: 267), *E. gracilis* Risbec (1928: 271; 1953: 139), and *E. evelinae* Marcus (1957: 466). *E. minuta* (Forbes and Goodsir, 1839), later on called *E. pygmaea* Iredale and O'Donoghue, 1923, is probably a variety of *pulchra* (Eliot, 1910: 171). In material of *pulchra* from Helgoland we found pads of cnidocysts on the tips of many, not all, cerata (Marcus, 1958b: 92, 94); *E. evelinae* does not have them. If they were constant in *pulchra*, *faurei* could not, as supposed (Pruvot-

Fol, 1954: 411), be a synonym of *pulchra*, because Hennebury (1925: 426, 427) verified the absence of cnidosacs in *faurei*, and would have seen pads of cnidocysts, if present. The two species of *Embletonia* whose reproductive organs are known, *pulchra* and *evelinae*, have a male copulatory organ without appendage.

Pruvot-Fol (*l. c.*) applies the name *Tenellia* A. Costa, 1866, to the species with more than one ceras to each group and with true cnidosacs. The type, *T. mediterranea* A. Costa (1866: 76), is a synonym of *T. pallida* (Alder and Hancock, 1855). The name *ventilabrum* Dalyell, 1855, which Pruvot-Fol (p. 413) uses for this species has been published in a work not available to us. *T. grayi* (Kent, 1869: 109) is another synonym of *pallida*. *T. fuscata* (Gould, 1870: 251) is an independent species with an unarmed tip of the penis and a hermaphroditic valve. Probably *Embletonia lanceolata* and *E. remigata* Gould (1870: 252) belong to *fuscata*. This can be inferred from Gould's text (see also p. 253). Bergh (1886a: 37) assumed the same synonymy, but united even *fuscata* with *pallida*. In any case the state of *remigata* which is held apart in Johnson's list (1934: 155) remains to be settled by comparative studies based upon material from Massachusetts. Externally, *remigata* is very similar to Meyer and Möbius' *pallida* (1865: Fig. 4) and to one of our present specimens. Therefore the latter was sectioned; it proved to be a typical *pallida* similar to the other slugs from Cananéia.

Suborder *EOLIDACEA*

Tribe CLEIOPROCTA

In this tribe, the radula has a cuspidate tooth in the Facelinidae and Favorinidae, a pectinate one in the Aeolidiidae. The right intestinal gland and its counterpart has a number of parallel branches each bearing a single series of cerata in the Facelinidae, and forms a simple two-legged arch, exceptionally one row (*Herviella* Baba 1949: 107, 180) in the Favorinidae. The basis for this system was found by Odhner (1939: 53, 77-78) and further data furnished by Macnae (1954: 7 ff.).

Family FACELINIDAE

We recently listed the Facelinidae with unarmed penis (Marcus 1958a: 57-58) to which the following species belongs.

Learchis Bergh, 1896

Penis blunt or conical, unarmed and without appendages; jaw with

denticulated masticatory border and without dorsal indentation; radular tooth with smooth median cusp flanked by at least 3 denticles; anterior angles of foot produced.

Type species. Learchis indica Bergh (1896: 386).

We amplify the diagnosis in several characters in order to separate the genus from other facelinids with unarmed penis. On the other hand, Bergh's indication "*rhinophoria annulata*" (1896: 385) is dropped, because annulated or perfoliated rhinophores do not justify generic separation in the Facelinidae and Favorinidae. We would even be inclined to allocate *Aeolidia dangeri* Risbec (1928: 252; 1953: 136), a species with smooth rhinophores, to *Learchis*, if the information upon the penis (p. 254) was more complete. *Rizzolia australis* Bergh (1884, p. 27) however surely belongs to *Learchis*.

Learchis poica, spec. nov.

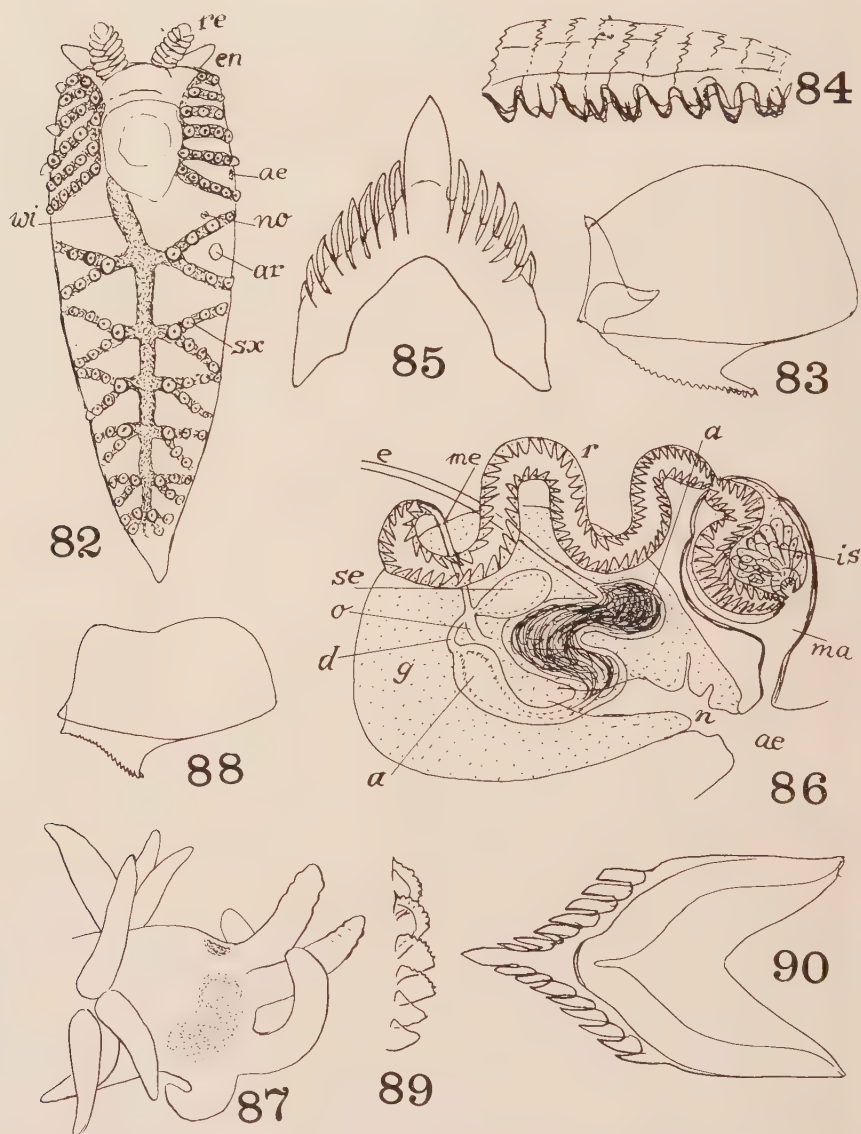
Figures 82-86

Occurrences. 1. East side of Virginia Key, among the growth on the constantly submerged panels hanging down from the pier of The Marine Laboratory, University of Miami, October 21-30, 1958, and among algae in front of the laboratory. 2. Among Hydrozoa from the fence around the pier of the laboratory, December 5, 1958. A total of 37 slugs with sinuous egg strings on hydroids from both localities. UMM 30.1814.

Description. The preserved animals are 1.5-8 mm long, up to 2.5 mm broad and 2.5 mm high at the pericardial eminence without cerata. These attain 3.5, the tentacles 1.5, the rhinophores 1, and the angles of the foot 0.8 mm.

The living slugs had paler or darker reddish brown diverticula of the digestive gland shining through the epidermis of the cerata, whose tips were white. The animals moved little and sometimes formed clusters on the hydroids, as we observed such of *Facelina coenda* of the same family in the upper littoral of S. Paulo. The preserved slugs have blackish or brownish branches of the digestive gland, and its diverticula are partly or entirely colored. The eyes are black, the up to 0.5 mm long cnidosacs white.

The tentacles (en) are smooth, the rhinophores (re) have 6-10 perfoliations. The foot (oo) is narrower than the body, has a bilabiate anterior border and produced lateral angles; the tail is short, less than 1 mm.



FIGURES 82-86. *Learchis poica*. FIG. 82. Dorsal view after removing the cerata. FIG. 83. Jaw. FIG. 84. Denticulation of masticatory border. FIG. 85. Radular tooth. FIG. 86. Diagram of reproductive organs. FIG. 87. *Dondice occidentalis*. Head of preserved young slug. FIG. 88. Jaw. FIG. 89. Denticles of masticatory border. FIG. 90. Radular tooth.

The cerata stand in about 8 groups, the hindmost of which are indistinctly separated. The middle of the back without cerata is narrower than either of the lateral areae bearing them. On the right and the anterior left liver the cerata form 5-6 rows with 2-8 cerata to each. The genital aperture (ae) lies ventrally to the two last rows of the right liver. The posterior digestive gland forms 6-7 arches with 10-12 cerata on the first arch and smaller numbers backwards. The renal pore (no) is located in the interhepatic space, near the anterior limb of the first right arch of the posterior liver. The anus (ar) is situated between the two limbs of this arch.

The high yellowish mandible has a ribbed masticatory border with irregular denticles somewhat similar to those of *Learchis australis* (Bergh, 1884: Pl. 9, Fig. 1). The radula comprises 18 teeth with a prominent median cusp flanked by 5-8 slightly curved denticles. The oesophagus is short; the wide stomach lies on the anterior mass of genital organs, its inner folds extend into the duct of the posterior digestive gland and the intestine. The latter emerges from the stomach in front on the right side. The diverticula of the liver in the cerata are smooth and connected with the cnidosacs by short canals. The contents of the stomach are cells, evidently of hydroids, with big nematocysts like those in the capitate tentacles of *Pennaria* (Hyman 1940, f. 114 E, on p. 401). The intestine contains digested matter and nematocysts. The cnidosacs lodge undischarged capsules of the type seen in the stomach.

In the hermaphrodite gland the male germ cells are central, the female ones peripheral. The long hermaphrodite duct (e) opens into a curved ampulla (a). The spermoviduct is short. The male duct (me) begins narrow, not glandular, then widens and becomes prostatic (r), and so it continues within the blunt penis included in the male atrium (ma). A penial gland (is) opens beside the male duct.

The nidamental duct (n) lies ventrally to the male organ; the genital aperture (ae) is in common. The spermatheca (se) is located at the innermost end of the oviduct, at its issue from the spermoviduct. Young specimens show that the species is protandrous.

Holotype. A series of transverse sections, one slide UMML 30.1815.

Discussion. The present species is the first Atlantic member of the genus. *L. indica* differs from *poica* by the cerata of the posterior liver which form groups, not arches. In *L. australis* there are 3-4 denticles

on either side of the median cusp of the radular tooth, the middle of the back is broad, and the hepatic diverticula are tuberos. ?*Learchis dangeri* has smooth rhinophores, and the diverticula are as in *australis*.

Family FAVORINIDAE
Subfamily Facalaninae

On the basis of Macnae (1954: 8) the Favorinidae with a single row of cerata on each liver branch (Favorinidae) can be separated from those with more than one row (Facalaninae). To the latter belongs *Dondice* Marcus (1958a: 61) with the type *D. occidentalis* (Engel, 1925: 73).

Dondice occidentalis (Engel, 1925)

Figures 87-90

Occurrence. East coast of Virginia Key, among the growth on the constantly submerged panels hanging down from the pier of The Marine Laboratory, University of Miami, October 29, 1958, one slug, and among algae in front of the laboratory, December 8, 1958, one slug. UMML 30.1816.

Further distribution. Jamaica (Engel, *l. c.*); coast of S. Paulo, Brazil (Marcus, 1958a: 65).

Description. Adult preserved slugs attain 27 mm; the present preserved animals are 2 and 3 mm long, hence young. Their height is 0.8 mm; the thin cerata are up to 2 mm in length, the tentacles 1 mm, the rhinophores 0.9 mm.

The slugs are whitish, except for the black eyes and the black epithelium covering the mandibles, which shines through the rather transparent skin.

The tentacles are thin and pointed, the rhinophores bear 3 indistinct rings in the smaller, 8 in the larger specimen. The anterior border of the foot is notched in the middle and transversely grooved; its lateral angles are produced; its hind end is pointed, especially in the larger slug whose tail is recently regenerated.

The cerata form 3-4 groups on either side. As the slugs are young, the cerata stand in a single row, so that the character of the subfamily was not yet recognizable. Notwithstanding, the determination is positive; it rests principally upon the peculiar concave dorsal margin of the jaw (Fig. 88).

Discussion. The Florida material has the same black pigmented epithe-

lium covering the jaws as the Brazilian specimens. The inferior border of the basal surface of the radular tooth, especially dark in Engel's samples (1925: Fig. 44), does not show this peculiarity, but agrees also in this character with the slugs from Brazil (Marcus, 1958a: 65).

Family AEOLIDIIDAE

Bergh's "*Aeolidiadae propriae*" (1892: 1018), the Cleioprocta with pectinate teeth of the radula, constitute but one family, because the position of the renal pore in relation to the anus (Odhner, 1939: 53, items III A and B) varies within one and the same population of *Spurilla neapolitana* (Marcus, 1957: Fig. 236) and to a lesser degree also in *Berghia coerulescens* (*ibid.*, Fig. 245).

Spurilla neapolitana (Delle Chiaje, 1823)

Fig. 91

Occurrences. East coast of Virginia Key: 1. Virginia Beach, on the underside of logs in tide pools around old mangrove roots, November 10, 1958 and January 26, 1959; 2. among the growth on the constantly submerged panels hanging down from the pier of The Marine Laboratory, University of Miami, October 29, 1958 and January 30, 1959; 3. in front of the laboratory, on a stick with green algae, November 25, 1958, and on the underside of logs in the intertidal zone, February 2, 1959. A total of 10 slugs. UMML 30.1817.

Further distribution. Mediterranean Sea including the Adria; Atlantic coast of France, Arcachon, and Morocco; Canary and Cape Verde Islands; Sargasso Sea; coast of Brazil, Alagoas and S. Paulo.

Remarks. The present preserved animals are up to 15 mm long, hence medium-sized. The species is recognizable by its ivory or pinkish color with reddish brown diverticula in the cerata. These are tipped with white and keeled on the side facing the mid line. All descriptions of living animals and colored figures, *e. g.* that of Vayssi re (1888: Pl. 1, Fig. 9) stress opaque white dots or spots as characteristic markings on cerata, head and back. These are even retained in the present preserved material.

Discussion. The above distribution agrees with Engel's discussion of the synonyms (1925: 46-49). Also *S. inornata* (A. Costa: 1866) which Vayssi re (1903: 86) and Engel (p. 50) consider as specifically different by reason of the lateral expansions of the radular plate does

not deserve a separate name, as the plates are also expanded in some Brazilian specimens (Marcus, 1955a: 186). *S. mograbiana* Pruvot-Fol (1953: 55) whose cerata are in part bulbous at their bases can not even be a variety. Probably *S. dakariensis* Pruvot-Fol, 1953 (*l. c.*) belongs to *neapolitana* too. The blackish brown ridge of the radular plate described for *dakariensis* occurs also in the older plates of the

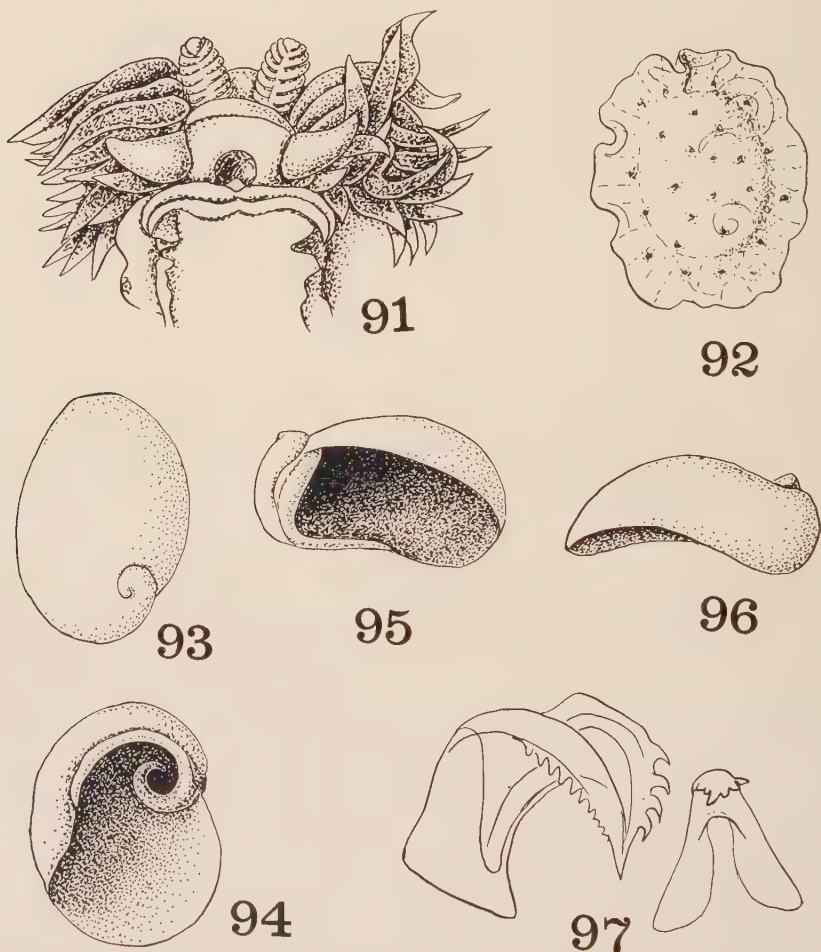


FIGURE 91. *Spurilla neapolitana*. Ventral view of fore end of preserved slug. FIG. 92. *Lamellaria perspicua*. Preserved animal. FIG. 93. Dorsal view of shell. FIG. 94. Ventral view of same. FIG. 95. Right side view of same. FIG. 96. Left side view of same. FIG. 97. Median and lateral tooth of radula.

present Floridian slugs. But as the denticles of the plates are very low in *dakariensis* and the jaws shorter and broader than in typical *neapolitana*, it may stand as a variety.

S. braziliانا MacFarland (1909: 91) was reduced to a variety with narrower body and smaller jaw (Engel, *l. c.*). There is a misprint in Engel's exposition (p. 48, line 14 from below), where "breiter" (broader) must be substituted by "schmäler" (narrower). Our first description of 41 slugs from the coast of S. Paulo (Marcus, 1955a: 184) eliminated the difference between *braziliانا* and *neapolitana* with regard to the proportions of the body, but confirmed the small size of the jaws in var. *braziliانا*.

A new examination of the question revealed that the mandible of MacFarland's specimen is 5 mm long in the drawings (Figs. 92, 93) and 3 mm in the text (p. 93). Certainly the latter is correct, because MacFarland said that the jaws of *neapolitana* are one-third larger than those of *braziliانا*. The maxima for Mediterranean *neapolitana* are however 5.5 and 6 mm long mandibles (Bergh 1883b: 17; 1886a: 27), and these refer to 36 and 35 mm long preserved animals. The length of the type specimen of *braziliانا* is 23 mm including the partly everted mouth parts. Vayssière's figure of a 1.9 mm long jaw (1888: Pl. 5, Fig. 51) belonged to his largest slug, nearly 40 mm when alive, about 20-25 mm preserved. Hence the type of *braziliانا* has the same body size and a bigger jaw.

The largest specimen from Florida is 18 mm long preserved and 3.5 mm long jaws; our largest slug from S. Paulo, preserved, 30 mm in length, has a 4 mm long mandible. Evidently the American slugs rarely attain the same maximum body size as those from the Mediterranean Sea, but the proportional length of the mandible is not distinctly inferior. Therefore we no longer separate the American populations as var. *braziliانا*.

Subclass *PROSOBRANCHIA*

Order *MESOGASTROPODA*

Family *LAMELLARIIDAE*

Subfamily *Lamellariinae*

Lamellaria perspicua (Linné, 1758)

Figures 92-97

Occurrence. East side of Virginia Key, Virginia Beach, on the underside of a log in a tide pool, January 26, 1959, one slug together with

Spurilla neapolitana, the bryozoon *Watersipora cucullata* (Busk, 1854), and the polyclad *Psuedoceros mopsus* (Marcus, 1953). UMML 30.1819.

Further distribution. 1. American: Florida, south of the Dry Tortugas, 73 m. (White, 1952: 106); intertidal zone of Southern Middle Brazil forma *mopsicolor* du Bois-Reymond Marcus, 1956a: 11); North Patagonia, 77 m (Bergh, 1894: 233); Strait of Magellan, 18 m (Bergh, 1898: 564); Southern Chile, Gulf of Ancud, 36 and 60 m (Marcus, 1959a). 2. Abroad: Eastern Atlantic Ocean, with exception of Arctic Regions and Baltic Sea; Mediterranean Sea; Indo-Westpacific Ocean, from the intertidal zone to 1287 m.

Description. The present specimen, a male, is preserved 7 mm long, 4.5 mm broad, and 4 mm high, hence young. It is white with scattered dark spots and dark viscera shining through the skin, whose bosses are slight. The 5 mm long foot is yellowish, bilabiate in front, and pointed behind.

The shell is smooth, transparent, almost without growth lines, and consists of two whorls. The nuclear whorl is little prominent. The suture is incised, and the columella open, so that the apex can be seen from below (Fig. 94). The parietal wall bears a crescent-shaped thickening. The measurements are in mm: length 4, 2; breadth 3,1; height 1,5; length of aperture 3,5.

The radula contains 41 rows. The 84 μ high rhachidian tooth has a longer left leg, to the left of the median cusp 2, and to the right 3 denticles. The upper cutting edge of the 150 μ high lateral teeth has 3-4 big denticles, the lower 9-11 finer ones.

Discussion. Several other species of *Lamellaria* have been described from Florida. *L. fernandinae* Dall (1927: 119), from 540 m off Northern Florida has a closed columella. *L. cochinnella* Perry (1940: 40) has a higher shell with a smaller aperture (Perry and Schwengel, 1955: Pl. 47, Fig. 326) than *perspicua*. The brilliant scarlet color of *cochinnella* is not a good specific character. Bergh (1853: 91; 1886c: 166) reported vermilion colored *perspicua*, and we have seen reddish brown *perspicua mopsicolor* from Chile (Marcus, 1959a). Also the smooth notum of *cochinnella* cannot be considered as a safe specific character, because it occurs in *perspicua* too (Bergh, 1853: 27). The shells distinguish *L. leucosphaera* Schwengel (1942: 62, Pl. 3, Fig. 8; Perry and Schwengel, 1955: Pl. 47, Fig. 327) and *L. koto* Schwengel (1944: 17-18, Pl. 1, Figs. 3-6a; Perry and Schwengel, 1955: Pl. 47,

Fig. 328) from the present specimen. It is certainly precarious to compare the shell of a young slug with those of adult animals, but the radulae of the previously published Floridian species were not described.

The median respiratory siphon of our slug, its unpigmented roof of the mantle cavity, and the considerable length of its everted efferent duct agree with *L. dubia* Bergh (1886b: 16-18, Pl. 1, Figs. 1-6), later on (*id.* 1887: 237) considered as a variety of *perspicua*. However a siphon projecting in the middle occurs in typical *perspicua* also (Bergh, 1853: 89: "subdextra vel media"), and the physiological state of the efferent duct is systematically indifferent. The absence of grey pigment in the roof of the mantle cavity is probably a juvenile character; neither *dubia* (Bergh, 1886b: 18: "testis destitute of ripe gonoblasts") nor the present male are full mature. In *dubia* the median teeth are higher than in *perspicua* (Bergh, 1887: 237). This significant quality does not occur in the present specimen, hence we consider it as typical *perspicua*.

ZOOGEOGRAPHIC REMARKS

As the study of biogeography depends more and more upon faunistic and ecological complexes (Hedgpeth, 1957: 359-360), it seems advisable to compare summarily the environmental factors for the area of Miami and the Brazilian localities where we have collected most frequently, that is, at Ilhabela and 14 km west of Ubatuba. The greatest interruption of a direct continuity between these two American Atlantic warm water regions is the Florida Strait, about 150 km wide and a little more than 300 fathoms deep. The coast of the Gulf of Mexico is continuous with that of the South Atlantic. Whether this connection has brought about the similar opisthobranch fauna of Florida and Brazil cannot be judged, because the opisthobranchs of the northern coast of the Gulf are nearly unknown. In present times, the winter temperatures on this coast (Hedgpeth, 1953: 141) make it improbable that many species common to Florida and Brazil occur there.

The mean minima at the localities of S. Paulo are colder than those of Florida (Smith, Williams, and Davis, 1950: 122; Stephenson, 1950: 394-395). The Miami area is near the lower limit for coral reef formation (Smith, 1943: 4); on the coast of S. Paulo there are no reefs. Mangrove fringed stretches of the shore occur both at Miami

and S. Paulo (Gerlach, 1958). *Sargassum* which is scarce on the Florida flats (Stephenson, 1950: 382) is abundant on the boulders of our coast; submarine forests of gorgonians (*ibid.*, p. 384 and Pl. 9) as in Florida do not occur here, though gorgonians are present. The Bryozoa on the panels at The Marine Laboratory, University of Miami (Smith, Williams, and Davis, 1950: 133) are the same species as occur on the coast of S. Paulo.

Dry summer weather which can intensify the evaporation and thereby increase the salinity of the inshore-waters at Miami (*l.c.*, p. 122, Table 2) practically do not occur on the coast of S. Paulo, where the warmest months coincide with the rainy season. General absence of high waves, a small mean tidal range considerably affected by wind (Stephenson, 1950: 365-367), and heavy fall of sediments are common traces of the compared areas. However the character of the sediments is different. In Biscayne Bay and Florida Bay they are calcareous and derived from the remains of organisms, at our localities they are terrigenous and washed in by frequent heavy rainfalls.

Opisthobranchs appear as characteristic forms of certain ecological units, e. g. *Cylichnella bidentata* on muddy sand, *Ganitus evelinae* in coarse clean sand, and some species of *Elysia* among *Halimeda*, *Caulerpa*, or *Codium*. In the sublittoral off Rio de Janeiro a great number of *Marionia cucullata* which feeds on alcyonarians was dredged on sandy bottom (Odhner, 1934: 294). Associations of species of *Armina* with their prey, sea pansies, are known from the coast of California and shallow bottoms of the Gulf of Mexico (Hedgpeth, 1953: 159).

Few opisthobranchs belong to the animals "important in marine sociology" (Steinbeck and Ricketts, 1941: 297), as they are usually not "common and obvious." Infrequency and inconspicuousness are indicated by the rarity of popular names for opisthobranchs. Such are sea-hares, or, in Brazil, ink-wells, for the species of *Aplysia*, coral-nesting and mangrove slugs (Allan, 1950: 368), or, in Brazil, stone slugs for Onchidiacea. These groups, represented by *Aplysia dactylomela* and *Onchidella floridana*, are mentioned in modern ecological surveys of South and Southeast Florida (Stephenson, 1950: 376; Voss, 1955: 211, 226). If there were stone flats in the Miami area, the orange, yellow, or ivory spirals of the egg ribbons of doridids, sometimes 7 cm in diameter, conspicuous during low tide, would have been recorded too.

Dr. Corrêa collected with the scope of systematic zoology and classic marine zoogeography (Ekman, 1935; 1953). Many of the American mollusks recorded from temperate Atlantic waters and the Gulf of Mexico or even from Cape Hatteras to the Gulf in Johnson's list (1934) are not expressly indicated from South Florida (Hedgpeth, 1953: 203). In these cases the species has either a continuous or a disjunct distribution (*ibid.*, p. 197), as for example *Polycera hummi* known from the Gulf coast of Florida and North Carolina. The corresponding species in the Miami area is *P. aurisula*.

The Floridian collection of 25 species including the identified *Aplysia dactylomela* was obtained from algae, e. g. *Acanthophora spicifera*, and others, and marine grasses (Voss, 1955: 227), under logs, and in sand. The panels hung from the pier (Smith, Williams, and Davis, 1950: 132, Fig. 2) made it possible to obtain material which was not exposed at low tide. Stones to be turned over are very scarce on the oceanic coast of Virginia Key. This accounts for the absence of dori-dids in the collection, though sponges are plentiful near the laboratory.

Specific ranges from New England to Brazil are not exemplified in the present collection. *Rhizorus persimilis*, a bottom form with wide bathymetric range, *Aplysia cervina*, and the transatlantic *A. dactylomela* illustrate the Cape Hatteras-Brazil type of distribution. Without identity of the species involved the following examples can be given of relations between Southeast Florida opisthobranchs with warm-temperate and boreal American Atlantic ones: *Polycerella conyna*, the already mentioned *Polycera aurisula*, and *Catriona maua*.

Contrary to these scarce relations of the Southeast Florida opisthobranchs with those of the northern coasts the similarity with the Brazilian fauna is striking. Of the present collection 72% occur in the Miami area and on the coast of S. Paulo. Hence the distribution of the opisthobranchs confirms the inclusion of Southern Florida and the coast of Middle Southern Brazil in one and the same littoral province by Hedgpeth (1957: Pl. 1). Only 4 of the 18 species from Miami and S. Paulo are known also from West Indian waters: *Gastropteron rubrum*, *Aplysia dactylomela*, *Aplysia cervina*, and *Dondice occidentalis*. The two first are widely distributed transatlantic species. Transatlantic means "crossing the Atlantic Ocean," not inhabitant of the Transatlantic province (Fischer, 1887: 177; Johnson, 1934: 8). The Caribbean discontinuity of so many Miami-S. Paulo species is certainly

not a zoogeographic fact, but a temporary result of the fragmentary state of our knowledge of West Indian opisthobranchs. Future collections, for example on the Virgin Islands, probably will fill this gap.

One species, *Tridachia schrammi*, must be added to the Miami-Caribbean species. It is not known from the Brazilian coast. *Tridachia* is closely related to *Tridachiella* from the Gulf of California and the Pacific coast of Panama (Bergh, 1894: 194, 195; MacFarland, 1924: 406; Steinbeck and Ricketts, 1941: 546). The paleogeographic Caribbean-Pacific sea connection (Ekman, 1935: 49; Hedgpeth, 1953: 123) up to the Middle Miocene explains this relationship. *Catriona maua* is allied to two boreal species, an Atlantic (*gymnota*) and a Pacific one (*columbiana*). We do not know any record of these or of *C. aurantia* (contrary to Abbott, 1955: 308) from Arctic seas. No *Catriona* from Japanese waters comes morphologically so near to that from the Vancouver region as the Atlantic forms. Hence the occurrence of *C. columbiana* testifies to the Caribbean-Pacific connection once more. The occurrence of *Doto uva* on the coast of S. Paulo, in the Miami area, and in 30 m depth in the Gulf of Ancud (Chile) proves that it is eurythermic. Its Chilean locality whose waters are intermediate between the warm-temperate Peruvian and North Chilean and the cold-temperate (antiboreal) South Chilean ones may as well be due to the Caribbean-Pacific connection as to the continuity of the East and West coast of South America.

The following 4 species of the present collection have a transatlantic distribution: *Gastropterion rubrum*, *Aplysia dactylomela*, *Stiliger (Ercolania) costai*, and *Spurilla neapolitana*. Considering the Miami-S. Paulo opisthobranch fauna as a whole 11% have a transatlantic distribution. Systematically disputable, sand dwelling, circumtropical, and species recorded from ship bottoms were not computed. In our opinion the transatlantic distribution cannot be explained on the basis of the present hydrography of the Atlantic Ocean. The distances between the continents and islands in question are too great for the transport of the larvae by currents, perhaps with exception of that between South Carolina and Bermuda. Moreover this group of islands lies out of the principal direction of the Florida Current, and even if larvae attained it, their offspring could not pass farther. It cannot be denied that drifting logs with hydroids and algae growing on them may transport and nourish opisthobranchs. For nudibranchs such as *Spurilla neapolitana* or *Berghia coerulescens* and for species of *Aplysia*

which possibly live for only one year (Hecht, 1895: 564; Eales, 1921: 10) such rafts will hardly serve, unless larvae hatched from eggs fastened to the raft settle on a substratum again. The metamorphosing larva no longer swims, but begins to creep, and must attain a raft for its further development. The species known to live 3-4 years (Pelse-neer, 1935: 619) are not in our transatlantic list. We never found any opisthobranchs in the growth on logs thrown on to the beach, but they may have been washed off by the breakers. The older ideas of land-bridges and the newer ones of continental drift or vertical movements caused by temperature (constriction hypothesis of Odhner, Geogr. Ann. Stockholm, 1934, quoted from Odhner, 1944: 33-45 and Malaise, 1957) agree on an Atlantic Ocean much narrower in Tertiary times than today and explain the present transatlantic distribution in opisthobranchs.

In Dr. Corrêa's collection a Florida-Indowestpacific affinity (Ekman, 1934: 326, 357; 1935: 80) is exemplified only by *Learchis poica* whose congeneric species were found at Amboina, Sydney, and perhaps New Caledonia.

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A PHORONID FROM THE GULF OF MEXICO

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ABSTRACT

Phoronis architecta Andrews, 1890 is reported from Alligator Harbor, Gulf coast of northern Florida. This is the first report of adult Phoronidea from the Gulf of Mexico.

INTRODUCTION

Faculty members and students of the Oceanographic Institute and Department of Biological Sciences of Florida State University have for some time noted adult phoronids in the vicinity of the Alligator Harbor Marine Laboratory, Franklin County, Gulf coast of northern Florida.

Adult phoronids are unknown from the Gulf of Mexico but Hedgpeth (1954) reported actinotroch larvae in plankton tows in Louisiana bays and off the Texas coast. He expressed the opinion that the larvae could not be identified to genus.

The phylum Phoronidea comprises coelomate, unsegmented animals which possess a lophophore, an epistome, a vascular system with haemoglobin, and two excretory organs. They live in tubes of their own manufacture. The group is widespread but very small, containing only two genera (Hilton, 1930) and approximately 22 species. The affinities of the phylum are not clear. The present paper is a contribution to the knowledge of this group.

This work was carried out under the guidance of Dr. Alan Kohn. The author is grateful for his suggestions and criticisms.

Phoronis architecta Andrews, 1890

The animals which were identified as *Phoronis architecta* Andrews (1890) were collected from intertidal regions of Alligator Harbor, a neutral estuary. Brooks and Cowles (1905) reported the density of *P. architecta* at Beaufort, North Carolina, the type locality, to be about 5 animals per square meter. In Alligator Harbor 8 samples, each of .11 square meter, were made across the intertidal zone in front of the Marine Laboratory. These collections yielded 2, 1, 1, 2, 6, 2, 3, and 0 phoronids, the mean density being about 1 individual per square meter.

Living Animal. The color, shape, and size of the living animals vary. Most specimens agreed with the coloration described by Brooks and

Cowles (1905), (anterior two thirds flesh color, posterior third dark-yellowish red). Some specimens autotomized their lophophores upon collection. These were uniformly light yellow in color, a condition which is associated with loss of blood pigment. The red color is apparently due to the distribution of blood vessels which contain haemoglobin in solution.

Externally, the cuticular annulations observed by Brooks and Cowles, while more apparent in the contracted animal, are also present when the animal is expanded. Waves of contractions rapidly change the shape of the animal, particularly the bulbous posterior end. Here the cuticle in healthy specimens is papillose in appearance. The papillae were seen to grasp the bottom of a glass dish into which specimens were placed after being removed from their tubes. Papillae may facilitate movement up and down the tube.

Four living animals measured 15.5, 14.3, 10.0, and 10.9 mm in length, but changes in shape render these measurements only approximate. The longest lophophore measured 1.4 mm. However, the length of the tentacles varies markedly due to contractions in this region. Lophophoral organs were not observed.

Identification. Taxonomy of Phoronidea is based on lophophoral and histological characteristics and in some cases on longitudinal muscle bundle counts (Marsden, 1959). Lophophores of living specimens from Alligator Harbor conformed with respect to appearance and number of tentacles with the original description of Andrews (1890). The arrangement of tentacles could be seen clearly on autotomized lophophores.

Sections stained with Harris' Hematoxylin and eosin were prepared from specimens fixed in Perenyi's fluid. Sections of the lophophore agreed in detail with the description of *Phoronis architecta* given by Brooks and Cowles (1905, p. 141, pl. XIII, fig. 63). Sections of the body region were also in general agreement with the earlier descriptions (Andrews, 1890; Brooks and Cowles, 1905). However, Marsden (1959) states that *P. architecta* may not be distinguishable from *P. psammophila* on the basis of lophophoral arrangement and general body structures. She suggests that the number of longitudinal muscle bundles may be used to distinguish these two species. The formula as cited by Marsden was originally used by de Selys Longchamps (1905) and is based on the number of muscle bundles in each of the following quadrants:

Oral Mesentery
 Left Oral Cavity Right Oral Cavity
 Left Lateral Mesentery Right Lateral Mesentery
 Left Anal Cavity Right Anal Cavity
 Anal Mesentery

TABLE 1
 COMPARISON OF MUSCLE BUNDLE COUNTS OF *Phoronis architecta*
 AND *P. psammophila*.

<i>P. architecta</i>				<i>P. psammophila</i>			
west coast (Los Angeles)		Gulf coast (Alligator Harbor)		east coast (Beaufort)		west coast (Los Angeles and Long Beach)	
15-16	15-17	12-13	12-13	13	12-16	9	9
6-9	7-9	6-7	6	4-9	5-6	4-5	4-5

Table 1 compares the muscle bundle counts of *Phoronis architecta* found at Beaufort (Marsden, 1959), at Alligator Harbor (4 specimens), the form from the west coast of North America that Marsden suggests is *P. architecta*, and *P. psammophila*, also from the west coast (Marsden, 1959).

The muscle bundle counts of *P. architecta* found in Alligator Harbor agree closely with those of *P. architecta* elsewhere.

Tube. The tube of *Phoronis architecta*, described in detail by Andrews (1890) and Brooks and Cowles (1905), is narrow and membranous. A single layer of affixed sand grains gives the tube a characteristic stiffness. The tubes may be straight or distorted, the latter condition due, according to Brooks and Cowles, to habitation of a firm substratum. Posteriorly, the tube is rounded and closed.

It was difficult to collect intact tubes. The longest collected measured 46 mm but was not complete. The tube length is probably at least four times that of the animal.

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TWO NEW MARINE TURBELLARIA FROM FLORIDA¹

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ABSTRACT

Descriptions are given of *Probursa moei*, n.sp. and *Hofstenia miamia*, n.sp. from the intertidal zone at Virginia Key, Miami, Florida. The former differs from *P. veneris* Hyman by more anterior ovaries and bursal-intestinal communication. *H. miamia* is near to *H. atroviridis* Bock from which it is distinguished by color, the ventral mouth, and the sunken nuclei of the pharyngeal epithelium.

INTRODUCTION

During my stay at The Marine Laboratory, University of Miami, Florida (Winter 1958/59) I collected two specimens of Turbellaria, both of which were found to represent new species. The first belongs to the Tricladida Maricola, Family Probursidae Hyman (1944, p. 6), the second to the acoelid genus *Hofstenia* Bock (1923, p. 3), whose place in the system of the Turbellaria was recently discussed by Papi (1957, p. 141).

The triclad I here name for Mr. Henry Allen Moe, vice-president and secretary general of the John Simon Guggenheim Memorial Foundation, N. Y., which awarded me a fellowship for studies in the United States. I wish to express to the Guggenheim Foundation my great indebtedness for their assistance.

The name of the second species is given in appreciation of the kindness and assistance of the staff of The Marine Laboratory, University of Miami.

Probursa moei, new species

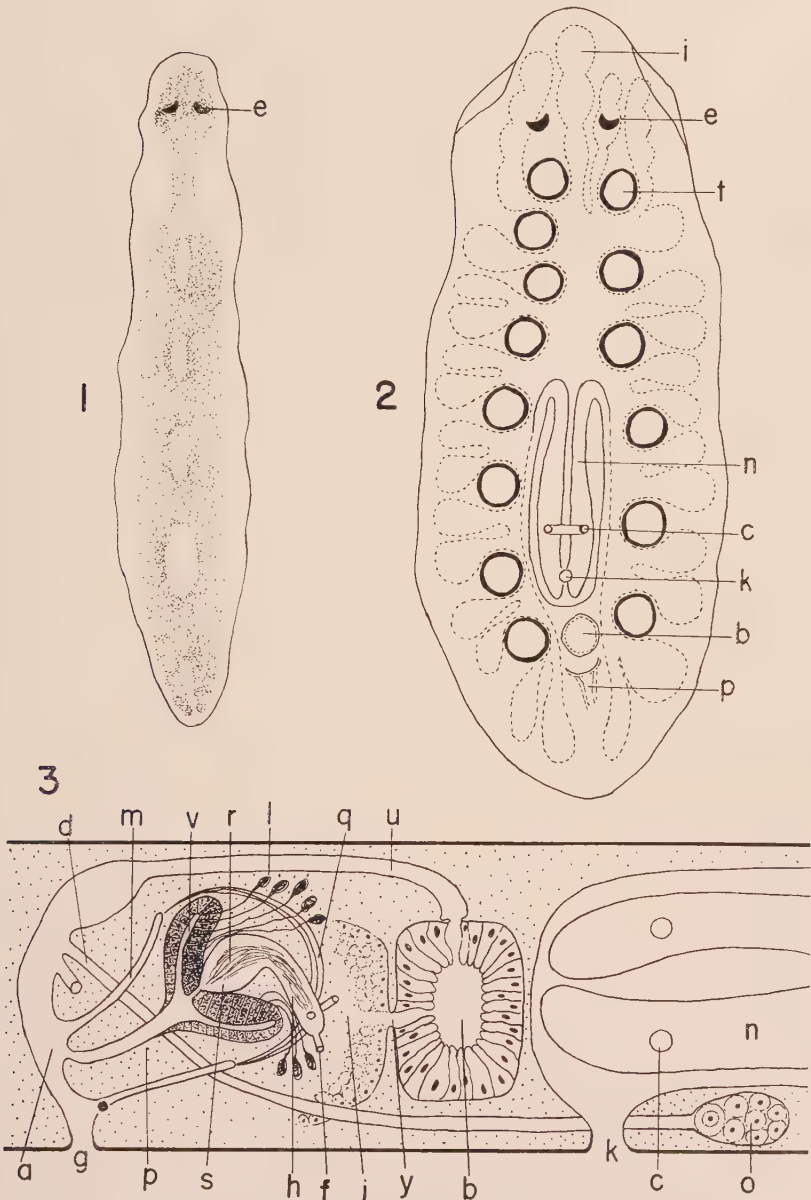
Figures 1-3

Locality. Virginia Key, Miami. Among algae together with many invertebrates on the panels hung for study of anti-fouling paint under the pier of The Marine Laboratory, University of Miami, January, 1959.

Material. Known only from the type.

Type. One set of 10 μ sagittal serial sections (four slides) under the

¹Contribution No. 269 from The Marine Laboratory, University of Miami.



FIGURES 1-3. *Probursa moei*, new species. Fig. 1. Dorsal aspect of living worm. Fig. 2. General structure in dorsal view from whole mount. Fig. 3. Combined sagittal section of copulatory apparatus. (For lettering of figures see p. 215)

number M1 deposited in the Department of Zoology of the Faculty of Philosophy, Sciences and Letters of the University of São Paulo, Brazil.

Description. External features: In the living state (Fig. 1) the body is elongate-oval in shape. The anterior transversely truncate end and the posterior rounded end have about the same width but they are a little narrower than the median part of the body. The whole wide margin of the body is thin and shows wavy movements as is common in many Polycladida. At the level of the eyes (Fig. 2e) the waves take the shape of auricles. True auricles seem to be absent. The color is brown except for the margins and five pigment-free zones situated medially (Fig. 1). The pigmented zone, almost square-shaped anteriorly, narrows behind the eyes and widens again in the posterior two thirds of the body. The pigment is still present after preservation with hot formalin.

The worm was about 5 mm long when fully extended and 0.5 mm in maximum width. Preserved it measured respectively 2.5 mm and 0.3 mm.

The two crescent-shaped eyes (Fig. 1e) lie within the cephalic square-shaped pigmented zone. They are not widely set apart from each other. Preservation does not dissolve the eye pigment.

The worm displayed leech-like movement and attached itself strongly to the pipette every time it had to be removed.

By transparency the living and later the cleared worm (Fig. 2) shows the pharynx (n), pharyngeal nerve ring (c), the branches of the gut (i), the eyes (e), testicles (t), bursa (b), and penial bulb (p). The digestive tract sends a median branch forward passing between the eyes and reaching almost to the anterior tip. The lateral anterior right intestinal branch of the gut is double.

Reproductive system: The present worm was young and in the beginning of the male phase, hence the glands of the female ducts were not yet developed. The testes (Fig. 2t) are dorsal, large, spherical bodies surrounded by dark pigment in the parenchyma. They are eight on the left and six on the right side. The first pair is situated closely behind the eyes (e). The last pair lies behind the pharyngeal chamber at the level of the copulatory apparatus. The whole series of testes occupies a lateral position at the bases of the digestive branches (i). The right and left efferent ducts (Fig. 3f) join to form a common

efferent duct (h) which opens into a small seminal vesicle (s). Both, the common efferent duct and seminal vesicle contain a few sperms (r) in their lumen. The large penial bulb (p) comprises an infundibuliform granule vesicle (v) in its distal part, whose wall is formed by a high epithelium filled with granular secretion. The penial papilla is elongated, unarmed, and projects into the common antrum (a) near the common gonopore (g). The penial papilla is surrounded by a large and deep male antrum (m). A curved muscular sphincter (q) closes the anterior side of the penial bulb. A few eosinophilous glands (l) open around the outlet of the seminal vesicle into the granule vesicle. The large bursa (b) is a roundish pouch between pharynx (n) and male organ with high homogeneous epithelium contrasting with the intestinal vacuolized cells. Its large bursal canal (u) runs first upwards over the penial bulb and then downwards to join the common antrum (a). The outer third of the bursal canal is wider than the inner two thirds. The bursa (b) is connected with one branch of the gut (i) by a genito-intestinal pore (y). The pair of elongate-oval ovaries (o) is situated ventrally and near the middle of the pharynx (n), closely in front of the pharyngeal nerve ring (c). The large and long oviducts leave the ovaries (o) proceed backwards ventrally to pharynx (n) and bursa (b), curve upwards at the level of the penial bulb (p) and enter the common antrum (a), ventrally to the bursal canal (u) as left and right ovovitelline ducts (d). The entire copulatory apparatus is directed backwards.

Discussion. The present species differs from the only other species of the genus, *P. veneris* Hyman (1944, p. 6), found on the Atlantic side of Long Island, N. Y., by the position of the ovaries which lie at the level of the posterior end of the pharyngeal chamber in *veneris*. Moreover there is no bursal-intestinal connection in the boreal species.

The last feature is rare among maricolous triclads, hitherto known only in *Miropilana trifasciata* Kato (1931, p. 3). More frequently the ovaries occur in a posterior position, a condition which links the triclads with the Proseriata. Besides the two species of *Probursa*, *Centrovarioplana tenuis* Westblad (1952, p. 46) and *Puiteca camica* du Bois-Reymond Marcus (1955, p. 20) have ovaries on either side of and behind the pharynx respectively.

Hofstenia miamia, new species

Figures 4-6

Locality. Virginia Key, Miami. Among algae from the intertidal zone

in front of The Marine Laboratory, University of Miami, November, 1958.

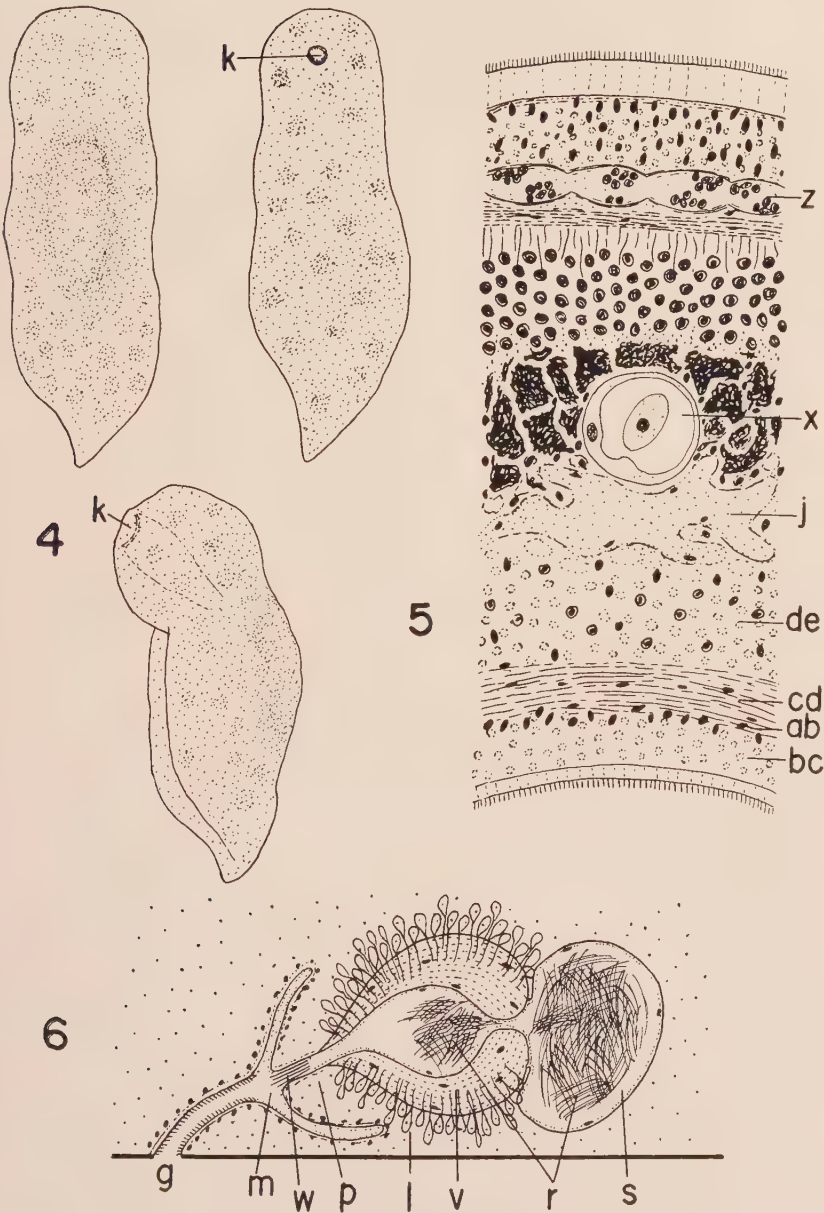
Material. Known only from the type.

Type. One set of 12 μ transverse serial sections (two slides) under the number M2 deposited in the Department of Zoology of the Faculty of Philosophy, Sciences and Letters of the University of São Paulo, Brazil.

Description. External features: The living animal (Fig. 4) was about 4 mm long, rather cylindrical, and 1.5 mm broad. After preservation it measured respectively 3.5 mm and 1 mm. Its ground color is white, irregularly speckled with brown. It has no eyes. The anterior end is rounded. The posterior end is pointed. Subterminally there is the cephalic pit, the common opening of the frontal gland. The large mouth (k) is distinctly ventral and is followed posteriorly by a single gonopore, that of the male antrum.

Internal features: The cephalic nervous system consists of a subepidermal ganglionic ring (Fig. 5z) interrupted only ventrally by the mouth. The statocyst (x) lies at the level of the mouth surrounded by the cephalic gland. Ventral to the statocyst there is a small mass of neurofibrils (j) with a few nerve cells. The mouth leads to a highly muscular pharynx about one third the length of the body. The pharynx is lined with an unfolded epithelium, the nuclei of which (ab) are sunken under the subepithelial layer of muscles which are longitudinal (bc). Then follows a thick circular (cd) and farther outwards another longitudinal layer (de). Radial fibres fasten the pharynx to the body wall. The digestive syncytium encloses several vacuoles in the hinder part of the body, but I could not trace any delimited intestinal cavity.

Reproductive system: The testes are scattered masses of germ cells situated dorsally and on the sides from close behind the gonopore to the level of the first ovaries. The male copulatory apparatus (Fig. 6) begins with a large, ventral, seminal vesicle (s) with a very thin wall and with its lumen filled with sperms (r). Close to the seminal vesicle follows the granule vesicle (v) also filled with sperms. Its wall is strongly muscular. Outside the muscles lies a mantle of eosinophilous gland cells (l) whose pink secretion penetrates the muscle layer. The succeeding penial muscular bulb (p) with narrow ciliated lumen bears a bundle of about 50 cuticular bristles (w), 70 μ in length, projecting into the ciliated male antrum which surrounds the penial papilla. The ovaries are scattered female cells in different phases of development.



FIGURES 4-6. *Hofstenia miamia*, new species. Fig. 4. Sketches of clarified worm. Fig. 5. Transverse section in region of statocyst. Fig. 6. Sagittal reconstruction of copulatory apparatus. (For lettering of figures see p. 215)

They occur on both sides of the ventral face from the level of the seminal vesicle backwards to the pre-caudal region. Each female cell is surrounded by a large number of voluminous follicular cells.

Discussion. The new species is near the type of the genus, *Hofstenia atroviridis* Bock, 1923, from the intertidal zone at Misaki, Sagami Bay, Japan. Important common characters of both species are: neurofibrils with a few nerve cells around the statocyst; pharyngeal muscles in three layers, inner longitudinal, middle annular, and outer longitudinal fibres; numerous groups of testes; male organ with seminal and granule vesicle. Specific differences are: subterminal (*atroviridis*) and ventral (*miamia*) mouth; pharyngeal epithelium with normal (*atroviridis*) and with sunken nuclei (*miamia*). The worms of both species are opaque and dark pigment occurs in the parenchyma of the preserved animals. The color in *atroviridis* is dark blackish green but this character is systematically insignificant. The size of *miamia* agrees with *atroviridis*.

Hofsteniola pardii Papi, 1957, from the Gulf of Naples and the coast of Livorno, is much smaller than *atroviridis* and *miamia*, viz. 2 mm alive. Its ventral mouth, ventral male opening, and sunken nuclei of the pharyngeal epithelium agree with *miamia*. But the absence of nervous tissue around the statocyst, pharyngeal musculature composed of only two layers, absence of granule vesicle, and two compact testes distinguish *pardii* so far from *atroviridis* and *miamia*, that the generic separation (Papi, 1957, p. 145) is justified.

Hofstenia tinga du Bois-Reymond Marcus, 1957, from the Island of São Sebastião on the coast of São Paulo, was described in the same year as *H. pardii*. The original sections of *tinga* were placed at my disposal for comparison with *miamia* and *pardii*. The size of *tinga*, 3 mm alive, is near that of *pardii*. The color of the living *tinga* was white, not the vivid reddish in the anterior third of the body of *pardii*. Ventral mouth, ventral opening of male antrum, and sunken nuclei of the pharyngeal epithelium of *tinga* are the same as in *miamia* and *pardii*. The small pharynx, one tenth of the length of the body, separates *tinga* from the other Hofsteniidae. The two pharyngeal muscle layers, subepithelial annular and outer longitudinal fibres, differ from *atroviridis* and *miamia*, and agree with *pardii*. The same applies to the absence of a so-called central nervous system in *tinga*. The statocyst lies embedded in the center of the cephalic gland (du Bois-Reymond Marcus, 1957, p. 172) without any accumulation of neurofibrils. The

only worm of *tinga* is in the advanced female phase. Therefore one cannot know whether the testes are numerous scattered groups of germ cells or a pair of compact organs. Besides the extension of the antrum around the penial bulb (*tinga*) or strongly muscular granule vesicle (Bock 1923, p. 29) which may be functional, the male organ of *tinga* agrees better with that of *atroviridis* and *miamia* than with that of *pardii*. The contents of these vesicles, some sperms and granules in *tinga*, are evidently residua of the male phase and cannot define their full function. Serially arranged ovaries occur in *atroviridis* and *pardii*, diffusely scattered ones in *tinga*. In *miamia* they are scattered in its anterior, serial in its posterior part.

Together with du Bois-Reymond Marcus (1957, p. 173) and Papi (1957, p. 142) I consider the position of *Hofstenia minuta* Palombi, as uncertain.

LETTERING OF THE FIGURES

a—common antrum.	k—mouth.
ab—sunken pharyngeal nuclei.	l—eosinophilous glands.
b—bursa.	m—male antrum.
bc—external longitudinal pharyngeal muscles.	n—pharynx.
c—pharyngeal nerve ring.	o—ovary.
cd—circular pharyngeal muscles.	p—penial bulb.
d—ovovitelline duct.	q—muscular sphincter.
de—internal longitudinal pharyngeal muscles.	r—sperms.
e—eye.	s—seminal vesicle.
f—efferent duct.	t—testes.
g—gonopore.	u—bursal canal.
h—common efferent duct.	v—granule vesicle.
i—intestinal branch.	w—cuticular bristles.
j—neurofibrils.	x—statocyst.
	y—genito-intestinal pore.
	z—brain.

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CALANOID AND CYCLOPOID COPEPODS COLLECTED FROM THE FLORIDA GULF COAST AND FLORIDA KEYS IN 1954 AND 1955¹

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ABSTRACT

Thirty-eight species of calanoid and cyclopoid copepods were collected in plankton tows made at intervals for approximately one year in seven nearshore areas along the Florida Gulf coast and Florida Keys. The temperature and salinity ranges and the mean number per liter were given for the common species. The six most wide-ranging and abundant species listed in order of frequency were *Paracalanus crassirostris*, *Paracalanus parvus*, *Oithona nana*, *Acartia tonsa*, *Oithona brevicornis* and *Oithona simplex*.

The widespread distribution of many species along the west coast between Marco and Cedar Key was noted, and the peculiar distribution of certain species along the northwest coast near Panama City and Pensacola was discussed in light of hydrographic conditions in this area of the coast.

INTRODUCTION

Systematic plankton sampling along the Florida Gulf coast has been conducted primarily in the area between Fort Myers and Alligator Harbor. Examination of the published accounts shows that little nearshore collecting has been done in the area between Alligator Harbor and Pensacola (a distance of 185 miles) on the northwest coast, and between Fort Myers and the southern end of the peninsula (a distance of 125 miles) on the west coast (Fig. 1). The present account enumerates the calanoid and cyclopoid copepods found in seasonal collections made along the entire Florida Gulf coast, and in one area on the Florida Keys, chiefly during 1954 and 1955.

The literature concerning Gulf of Mexico copepods has recently been reviewed by Schmitt (1954). His bibliography includes thirty-eight publications many of which concern nonplankton species. Since Schmitt's review, several papers have appeared on Gulf species. One of these is an ecological investigation (Grice, 1956) and the others are chiefly taxonomic studies (Fleminger and Bowman, 1956; Fleminger, 1957 a, b, c).

METHODS

Six widely spaced areas on the Florida Gulf coast and one area on the Florida Keys were selected for the purpose of making plankton

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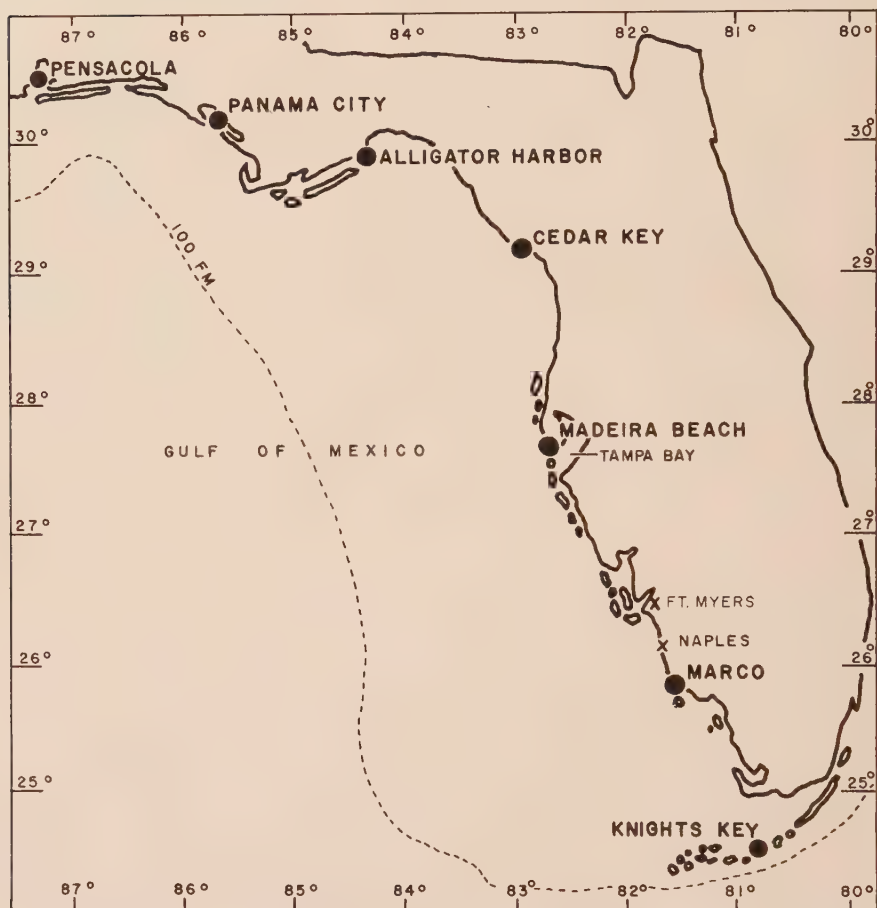


FIGURE 1. Map of Florida showing the bases (indicated by dots) from which plankton collecting stations A, B and C were established.

collections (Fig. 1). The six bases on the Gulf coast were Pensacola, Panama City, Alligator Harbor, Cedar Key, Madeira Beach and Marco. Knights Key was selected as a base on the Florida Keys. From each Gulf coast base, collecting stations were established as follows: station A was located within the bay or river near the base, station B was located $\frac{1}{2}$ to one mile seaward of the inlet of the river or bay and station C was located three to four miles seaward of the inlet. At Knights Key, station A was situated approximately one mile north of the Key on the Gulf of Mexico side, and station B was located about

$\frac{1}{2}$ mile south of the Key on the Atlantic side.

Seasonal plankton collections (fall, winter, spring and summer) were made at Panama City, Cedar Key and Marco. Winter and summer collections were made at Pensacola, Alligator Harbor, Madeira Beach and Knights Key.

Plankton tows were made with a Clarke-Bumpus plankton sampler and a No. 10 net. Collections were also made with a $\frac{1}{2}$ meter net of No. 10 bolting cloth. At most stations, the nets were lowered to near the bottom and gradually raised to the surface so as to allow a time lapse of approximately ten minutes. Water temperature and transparency were determined at each station and a water sample obtained for salinity. These hydrographic data and the exact position where the plankton tows were obtained are on file at the Oceanographic Institute, Florida State University.

Aliquots of each plankton sample were removed by means of a piston pipette, and identifications and counts were made of each species with compound and binocular microscopes. The species list for each station was determined by combining the species taken by the $\frac{1}{2}$ meter and Clarke-Bumpus nets. The term "sample" therefore refers to the copepods collected by both nets at a given station. A total of sixty such "samples" were collected.

I wish to thank Dr. Thomas E. Bowman for help in identifying certain species and Dr. Harry C. Yeatman for reading the manuscript. The Charleston Scientific and Cultural Society and the Research Council of Florida State University provided financial assistance that greatly facilitated the investigation.

NOTES ON SPECIES

For each common species; that is, those copepods occurring in thirty or more samples, mention will be made of: 1. temperature and salinity ranges, 2. gross distribution along the Florida coast, 3. numerical abundance, and 4. reproductive periods. Since the distribution of many of the copepods has been discussed previously (Grice, 1956), only distribution records of certain of the common species will be cited. Thirty-eight calanoid and cyclopoid copepods, three of which were not specifically identified, were recorded in the collections. Table 1 lists the species found at each base. The mean number given for each species is based on the number of Clarke-Bumpus samples in which it was represented by 0.1 individuals per liter or more.

TABLE 1

COPEPOD SPECIES ENCOUNTERED IN PLANKTON SAMPLES COLLECTED FROM THE
FLORIDA WEST COAST AND FLORIDA KEYS AND THEIR DISTRIBUTION.

Species	Distribution ¹
Calanoida:	
1. <i>Nannocalanus minor</i> (Claus)	P.C.
2. <i>Undinula vulgaris</i> (Dana)	P.C., Pen., K.K.
3. <i>Eucalanus attenuatus</i> (Dana)	P.C.
4. <i>E. pileatus</i> Giesbrecht	P.C., Pen., A.H.
5. <i>Paracalanus parvus</i> (Claus)	All bases.
6. <i>P. aculeatus</i> Giesbrecht	P.C., Pen.
7. <i>P. crassirostris</i> Dahl	All bases.
8. <i>Clausocalanus furcatus</i> (Brady)	P.C., Pen., K.K.
9. <i>Euchaeta marina</i> (Prestandrea)	P.C., Pen.
10. <i>Scolecithrix danae</i> (Lubbock)	P.C., Pen.
11. <i>Temora stylifera</i> (Dana)	P.C.
12. <i>T. turbinata</i> (Dana)	All bases.
13. <i>Eurytemora hirundoides</i> (Nordquis)	C.K.
14. <i>Centropages hamatus</i> (Lilljeborg)	All bases except M., K.K.
15. <i>Centropages furcatus</i> (Dana)	All bases except K.K.
16. <i>Pseudodiaptomus coronatus</i> Williams	All bases except P.C., Pen., K.K.
17. <i>Calanopia americana</i> Dahl	All bases except C.K., Pen., A.H.
18. <i>Labidocera aestiva</i> Wheeler	All bases.
19. <i>L. scotti</i> Giesbrecht	All bases except P.C., Pen.
20. <i>L. mirabilis</i> Fleminger	C.K., M., K.K.
21. <i>Pontella pennata</i> Wilson	M.B.
22. <i>Acartia spinata</i> Esterly	K.K.
23. <i>A. tonsa</i> Dana	All bases.
24. <i>Tortanus setacaudatus</i> Williams	C.K., M.
Cyclopoida:	
25. <i>Oithona brevicornis</i> Giesbrecht	All bases.
26. <i>O. nana</i> Giesbrecht	All bases.
27. <i>O. plumifera</i> Baird	P.C., Pen., K.K.
28. <i>O. simplex</i> Farran	All bases.
29. <i>Saphirella</i> sp ²	All bases except C.K., M., M.B.
30. <i>Macrocheiron</i> ? sp.	A.H.
31. <i>Kelleria</i> sp.	P.C., Pen.
32. <i>Oncaea venusta</i> Philippi	P.C., Pen., K.K.
33. <i>O. curta</i> Sars	P.C., Pen., A.H.
34. <i>Corycaeus speciosus</i> Dana	P.C.
35. <i>C. giesbrechti</i> Dahl	P.C., M., K.K.
36. <i>C. amazonicus</i> Dahl	All bases.
37. <i>C. americanus</i> Wilson	All bases except M.
38. <i>Farranula carinata</i> (Giesbrecht)	P.C.

¹Abbreviations refer to collecting bases (see Fig. 1).²Thought to be juvenile *Hemicyclops* by Nicholls (1944).

Acartia tonsa

Temperature range: 10.0°-32.0°C.

Salinity range: 24.4-38.4‰.

Occurring in 53 of the 60 plankton samples, *A. tonsa* was a widely distributed species. It was consistently absent from only those collections made at stations B and C, Panama City. Although present at most stations at the other bases, *A. tonsa* was generally found in greater numbers in the bays and rivers (station A) than in the more open waters (stations B and C). This was particularly evident at Panama City where, as indicated, none was ever observed at station C and only a few specimens were observed in one station B collection.

The abundance of this species varied from less than 1.0 to more than 17.0 individuals per liter. A mean number of 2.9 individuals per liter was calculated.

A. tonsa probably breeds the year-round along the west coast of Florida. Spermatophore-bearing females were observed in most collections. Greater numbers of such females were encountered in winter samples. Woodmansee (1958) estimated that this species produces about 11 generations a year in Biscayne Bay, Florida.

Corycaeus amazonicus

Temperature range: 15.5°-32.0°C.

Salinity range: 29.0-38.4‰.

This species occurred at one time or another in samples collected at each base. Although a frequent member of the plankton, it was poorly represented numerically. In no sample did it exceed 1.0 per liter. The mean calculated number was approximately 0.2 individuals per liter and it was present in 31 samples.

Ovigerous females were found at most bases in summer. Egg-bearing females were also noted in October, December and June collections made at Marco.

Corycaeus americanus

Temperature range: 10.0°-31.0°C.

Salinity range: 26.3-38.1‰.

Like *C. amazonicus* this was a widely distributed species. It occurred nearly year-round at all bases except Marco where none was observed.

C. americanus occurred in slightly larger numbers than *C. amazonicus*. The mean number calculated for the former species was approxi-

mately 0.5 per liter. It was present in 30 samples, 17 of which also contained *C. amazonicus*.

Egg-bearing females were noted in collections made throughout the year at Panama City and in winter and summer at Alligator Harbor and Madeira Beach.

Oithona brevicornis

Temperature range: 10.0°-30.0°C.

Salinity range: 24.4-38.4‰.

This was a widely distributed species. It occurred in at least 1 of the 3 samples taken at each base in each season excepting Knights Key where none was observed in winter.

In comparison with other common species, *O. brevicornis* occurred in large numbers. The mean calculated number was 3.5 individuals per liter, and it was present in 42 collections. In terms of mean number, it was the third most abundant species encountered.

O. brevicornis apparently breeds throughout the year in Florida waters. Ovigerous females were collected in all seasons.

Oithona nana

Temperature range: 11.0°-32.0°C.

Salinity range: 29.0-38.4‰.

This is another species with a wide range. It occurred in samples collected at all bases throughout the year.

Although *O. nana* was present more frequently (55 samples) than *O. brevicornis*, the former was generally the less abundant of the two species. The mean calculated number per liter of *O. nana* was 1.9.

It is probable that this species breeds throughout the year. Ovigerous females were found in most collections.

Oithona simplex

Temperature range: 11.0°-32.0°C.

Salinity range: 24.4-38.4‰.

Like the preceding two species of this genus, *O. simplex* was collected all along the coast. Individuals of this species were recorded in 39 samples. The mean calculated number was 3.6 individuals per liter. It was the second most abundant species.

This is apparently a prolific species, but ovigerous females were actually observed at only two bases, Cedar Key (fall) and Marco (winter).

O. simplex has probably been overlooked in other plankton studies along the west Florida coast, including my own (Grice, 1956), because of its small size or its superficial similarity to juveniles of other species of *Oithona*. As far as I can determine, the present record is the first from the coast of North America.

Paracalanus crassirostris

Temperature range: 10.0°-32.0°C.

Salinity range: 24.4-38.4‰.

This was the most abundant and widespread species which occurred along the coast. It was found in all but one collection. The mean calculated number was 4.8 individuals per liter. In several samples the number exceeded 10.0 per liter.

Juveniles of this species were observed in most collections. Only 3 spermatophore-bearing females were observed, however.

This species has been recorded previously from brackish waters of south Florida (Davis and Williams, 1950) and from several localities along the Florida coast (Davis, 1950). It has also been reported from Alligator Harbor (Grice, 1956).

Paracalanus parvus

Temperature range: 10.0°-32.0°C.

Salinity range: 24.4-38.4‰.

P. parvus was a characteristic member of the copepod plankton. It occurred throughout the year at all bases and was the species encountered second most frequently (55 samples). The mean calculated number per liter was 2.2.

This species apparently breeds throughout the year. Juvenile individuals were observed in most samples, and in many they exceeded the number of adults.

Temora turbinata

Temperature range: 11.5°-32.0°C.

Salinity range: 29.2-38.4‰.

This species occurred at most bases but usually in small numbers. It was observed in 33 collections. The calculated mean abundance was 1.1 individuals per liter. Juveniles were observed in both fall and winter collections.

Other species. In general the following species were not numerically

important. Some information was obtained on reproduction for certain of them.

Spermatophore-bearing *Acartia spinata* were found in the June collections from Knights Key. Female *Centropages furcatus* bearing spermatophores were collected throughout the year at Panama City and in summer at the other bases where they occurred. *Centropages hamatus* apparently breeds in winter. Females with attached spermatophores were encountered in December collections from Pensacola, Panama City and Alligator Harbor. Ovigerous *Corycaeus giesbrechti* were collected at Panama City in the fall. Female *Farranula carinata* with attached spermatophores were encountered in a fall collection from Panama City. Spermatophore-bearing *Labidocera aestiva* were observed in spring collections from Panama City and summer collections from Pensacola and Madeira Beach. Ovigerous *Oithona plumifera* were found in summer collections from Panama City. Egg-bearing *Oncaea curta* were encountered in winter, spring and summer collections made at Panama City. Ovigerous *Oncaea venusta* were found throughout the year at Panama City and in summer at Pensacola. Egg-bearing *Pseudodiaptomus coronatus* were observed in winter collections made at Madeira Beach and Marco, and in summer collections made at Cedar Key. Spermatophore-bearing *Undinula vulgaris* were observed in most collections from Panama City which contained this species and in summer collections made at Pensacola.

COASTWISE DISTRIBUTION

The six most widely distributed copepods along the Florida Gulf coast, *Paracalanus crassirostris*, *Paracalanus parvus*, *Oithona nana*, *Acartia tonsa*, *Oithona brevicornis* and *Oithona simplex*, were also numerically the most important species. Although the abundance of these species fluctuated considerably, they did not appear to have well-defined periods of reproduction, nor was their occurrence restricted to narrow temperature and salinity ranges. In view of their abundance and distribution, these six species are probably the most important copepods in the economy of the nearshore waters of the Florida Gulf coast.

Besides the above-mentioned species, several other but less common ones (e.g. *Labidocera scotti*, *Pseudodiaptomus coronatus*, and *Tortanus setacaudatus*) occurred both at the southernmost base, Marco, and at the northernmost base, Cedar Key, of the peninsula proper. The collections obtained from these two areas and from Madeira Beach

were usually dominated by essentially the same coastal and estuarine species.

In contrast to the comparatively few species encountered in the collections obtained from Marco, Madeira Beach and Cedar Key, the Panama City and Pensacola collections usually contained a greater number of species. The six samples which yielded fifteen or more species, for example, were collected at Panama City and Pensacola. In addition to the six species mentioned above, the Panama City and Pensacola collections contained certain copepods which were found nowhere else along the coast. Five of these (*Corycaeus speciosus*, *Eucalanus attenuatus*, *Farranula carinata*, *Temora stylifera* and *Nannocalanus minor*) were collected only at Panama City and four (*Euchaeta marina*, *Kelleria* sp., *Scolecithrix danae*, and *Paracalanus aculeatus*) were found in both Panama City and Pensacola collections. Moreover, certain other species (e.g. *Centropages furcatus*) which occurred seasonally at other bases were encountered in collections obtained throughout the year at Panama City.

These peculiarities of species distribution may be related to environmental conditions along the northwest Florida coast. Little, however, is known of the hydrography of this region. Salinity data collected during this investigation (stations B and C) and some additional such data provided by the U. S. Navy indicate that salinity remains high (about 33‰ or more) off Panama City. Several readings in excess of 36‰ were obtained during the present study. Water temperatures were somewhat warmer near Panama City than at certain other northern bases. Available data also show that the range in temperature near Panama City is small in comparison with Cedar Key and Alligator Harbor, two northern bases. The relatively small observed temperature range at stations B and C off Panama City may be related to the water depths, which were greater at these stations than at corresponding stations situated off Cedar Key and Alligator Harbor. Possibly significant in this respect is the narrow width of the continental shelf along the northwest coast (Fig. 1).

The relatively high salinity and warm water in the Panama City area may permit the existence of more typically offshore planktonic species which augment the usual nearshore copepod fauna. Noteworthy in this respect was the presence of salps in several collections obtained from station A at Panama City.

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LARVAL TUNAS FROM THE FLORIDA CURRENT

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ABSTRACT

The collection of larval fish made in the Florida Current from May 1951 to October 1956 by the personnel of The Marine Laboratory contained 146 tunas. The following were represented: (1) tuna, *Thunnus* sp. or spp., most likely young of the bluefin tuna *T. thynnus*; (2) oceanic skipjack, *Katsuwonus pelamis*; (3) little tunny, *Euthynnus alletteratus*; (4) frigate mackerel, *Auxis thazard*; and (5) 13 unidentified scombroid larvae. Capture of these larval fishes indicates that several tunas spawn in the Florida Current between March and October.

INTRODUCTION AND ACKNOWLEDGMENTS

This paper is one of a series, originated by The Marine Laboratory, University of Miami, devoted to the study of life histories of the marine fishes of the Florida Current. Since February 1952, larval fishes have been collected by workers of The Marine Laboratory on a routine basis. The results in this paper are based on material from the collection of the National Geographic Society-Marine Laboratory, University of Miami Pelagic Fish Life History Program.

A number of larval scombroids have been collected in the Straits of Florida in the course of this program. The author was able to separate and identify young forms of several species of tunas.

I wish to thank Dr. Gilbert L. Voss of The Marine Laboratory for loan to the Inter-American Tropical Tuna Commission of the collection of larval scombroids. I am grateful to Dr. F. G. Walton Smith, Director, Marine Laboratory, for permission to publish the findings.

METHODS AND MATERIALS

The material upon which this study is based was collected by personnel of The Marine Laboratory in the Straits of Florida between May 1952 and September 1956.

The entire material originates from plankton tows made mostly at routine stations. Miller *et al.* (1953), Voss (1954), Bsharah (1957), and McKenney (1959) have already described the methods employed by The Marine Laboratory in the collection of plankton.

Table 1 lists the stations at which larval tunas were taken, together with details as to the time, place, and depth of tow.

All specimens, which were preserved in formalin, were examined under a binocular microscope and measurements were made with a

TABLE 1
LARVAL TUNAS FROM THE FLORIDA CURRENT

Station No.	Date	Latitude N.	Longitude W.	Time	Depth (m)	Thunnus sp. indet.		Katsuwonus pelamis		Auxis thazard		Euthynnus alletteratus		Unidentified	
						No.	Size (mm)	No.	Size (mm)	No.	Size (mm)	No.	Size (mm)	No.	Size (mm)
NG-25,A	5,26,1951	25°35'	79°56'	1105	25	2	7.3,7.4							1	5.2
NG-26,A	6,5,1951	"	"	1020	25	4	6.7-8.0								
NG-27,B	6,19,1951	"	"	0915	45	1	5.6								
NG-28,A	7,3,1951	"	"	0925	40			3	5.4-13.0						
NG-29,A	7,13,1951	"	"	0900	31	1	5.0								
NG-30,A	8,2,1951	"	"	0945	25	1	9.1								
NG-31	8,7,1951	25°34.5'	79°55'	1107	0	1	5.5								
NG-32,5	8,13,1951	"	"	1140	167	1	5.2								
NG-32,19	8,13,1951	"	"	2250	40	3	4.6-6.0	1	3.9					1	3.8
NG-32,26	8,14,1951	"	"	0330	75	1	8.5							1	8.0
NG-32,37	8,14,1951	"	"	0730	50									2	7.0,7.7
NG-40,A	3,3,1952	"	"	0845	0										
SL-14,E-0	3,20,1953	25°35'	79°25'	0800	0	1	6.8								
SL-15,A-1	4,23,1953	"	"	2020	46			1	5.7						
SL-15,B-0	4,23,1953	"	"	2255	0			1	6.9						
SL-15,C-0	4,24,1953	"	"	0250	0			1	6.4					1	4.8
SL-16,A-0	5,21,1953	"	"	0310	0									1	5.2
SL-16,A-1	5,21,1953	"	"	0310	55	1	5.9								
SL-16,B-0	5,21,1953	"	"	0913	0	3	4.9-7.9								
SL-16,B-1	5,21,1953	"	"	0913	55	1	6.1			1	4.7				
SL-16,C-3	5,21,1953	"	"	1655	238									1	5.7
SL-16,D-0	5,21,1953	"	"	2035	0	3	5.7-6.1								
SL-16,D-4	5,21,1953	"	"	2140	366			1	4.5						
SL-17,A-0	6,11,1953	"	"	1640	0	4	5.5-8.9								
SL-17,B-0	6,11,1953	"	"	1838	0	15	4.2-8.5							1	5.3
SL-17,B-1	6,11,1953	"	"	1838	68	1	5.4								
SL-17,C-0	6,11,1953	"	"	2315	0	3	6.6-10.0			1	5.3				
SL-17,C-3	6,12,1953	"	"	0015	274	6	4.0-6.5								

TABLE 1 (Continued)
LARVAL TUNAS FROM THE FLORIDA CURRENT

SL-17,D-0	6,12,1953	"	"	0235	0	7	4.4-6.6	1	7.0	
SL-17,E-0	6,12,1953	"	"	0540	0	2	5.0,5.4			
SL-17,F-1	6,12,1953	"	"	1015	68			1	8.8	
SL-18,C-0	7,2,1953	"	"	0610	0	4	4.2-5.3			
SL-18,D-0	7,2,1953	"	"	1040	0					1 4.0
SL-18,E-0	7,2,1953	"	"	1515	0	3	4.3-7.2			
SL-19,A-0	8,13,1953	"	"	1430	0	3	5.0-6.2			
SL-19,B-0	8,13,1953	"	"	2027	0	2	6.5,6.9			
SL-19,B-1	8,13,1953	"	"	2027	48	1	4.7			
SL-19,B-3	8,13,1953	"	"	2138	274					
SL-19,C-0	8,14,1953	"	"	0130	0	1	6.2			1 5.0
SL-19,C-5	8,14,1953	"	"	0408	448			1	7.0	
SL-19,D-0	8,14,1953	"	"	0640	0	2	6.5,9.0			
SL-19,D-2	8,14,1953	"	"	0640	137			1	4.7	
SL-19,E-0	8,14,1953	"	"	0640	0	6	5.0-6.5			
FR-47	5,7,1955	25°34.5'	79°19.3'	1015	0	1	5.4			
FR-57	7,24,1955	25°43.5'	79°19.7'	0938	0	1	5.0			
SL-37,C-1	8,8,1955	25°35'	79°25'	2315	50					
FR-62	8,29,1955	25°03'	75°20'	1235	0	1	7.8			1 5.6
SL-40,A-3	10,4,1955	25°35'	79°25'	2345	144					
SL-40,B-7	10,5,1955	"	"	0145	288	1	7.1	1	7.4	
SUPL-58	4,5,1956	25°34.5'	79°19.7'	0907	0			1	7.4	
SUPL-66	6,5,1956	25°43.5'	79°19.7'	1830	0	13	4.0-5.5			
SUPL-74	6,6,1956	25°40'	79°19.5'	1820	0	6	4.5-7.5			
SUPL-78	6,6,1956	"	"	1745	0	1	6.0			
SUPL-82	5,7,1956	"	"	1810	0					
SUPL-83	5,8,1956	25°46.2'	79°19.5'	1745	0	1	4.8			1 4.6
SUPL-86	6,11,1956	25°43.5'	79°19.7'	1810	0	3	4.9-5.5			
SUPL-88	6,13,1956	25°32.5'	79°18'	1655	0	1	4.9			
SUPL-102	5,15,1956	25°33.3'	79°17.5'	1800	0	1	7.9			
SUPL-107	5,16,1956	25°40'	79°19.5'	1845	0	2	4.9			
SL-45,A-0	9,13,1956	25°35'	79°25'	0400	0	1	7.3			

micrometer eyepiece. The measurement of total length represents the direct distance from the tip of the snout to the tip of the shortest median ray of the caudal fin.

For convenience, the author followed the taxonomic nomenclature of Rivas (1951), with the exception of employing *Thunnus albacares* in place of *T. argentinatus* for the Atlantic yellowfin tuna.

RESULTS

Identification of young tunas. A total of 146 larval scombroids are present in all collections, among which the following genera and species have been identified: *Thunnus* sp. or spp., *Katsuwonus pelamis*, *Auxis thazard*, and *Euthynnus alletteratus*. In addition, 13 larvae, ranging in length from 3.8 to 8.0 mm, could not be assigned to any of the genera or species. These individuals were mostly damaged or poorly preserved.

Thunnus sp. *indet.* One hundred and seventeen individuals ranging in total length from 4.0 to 10.0 mm are present in this group. These larvae were collected between March and October, with the main catches between May and June (Table 1). All these specimens coincide in their general appearance with published descriptions and illustrations of larval *Thunnus* (*sensu lato*). Since even the largest individuals are too small for critical examination of bony parts, or for establishment of the number of gill rakers, specific identification has not been attempted.

Klawe and Shimada (1959) have discussed possibilities of occurrence of various species of the genus *Thunnus* in waters of the Gulf of Mexico. In general the same arguments are valid for waters of Straits of Florida, the difference being that the occurrence of *T. obesus*, bigeye tuna, in those waters has been substantiated (Mather and Gibbs, 1958). Therefore, as many as five species of genus *Thunnus* may be encountered in the Straits of Florida: the bluefin tuna *T. thynnus*, yellowfin tuna *T. albacares*, blackfin tuna *T. atlanticus*, bigeye tuna *T. obesus*, and albacore *T. alalunga*. Of these, at the present time, albacore has been caught only off Jamaica and Hispanola in the western Atlantic Ocean (Bullis and Mather, 1956). As Rivas (1954) has presented an array of evidence that *T. thynnus* spawn in the Straits of Florida in May and early June, very possibly many or all of the *Thunnus* larvae in this collection are those of *T. thynnus*.

Oceanic skipjack, *Katsuwonus pelamis*. This species is represented by 11 specimens of total lengths 3.9 to 13.0 mm. These individuals

were captured in the months of April, June, August, and October (Table 1).

Frigate mackerel, *Auxis thazard*. Four specimens of frigate mackerel are present in the collection. These individuals range in size from 4.7 to 7.0 mm. These larvae were captured in May, June, and August (Table 1).

Little tunny, *Euthynnus alletteratus*. A single individual of length 8.8 mm was caught in June (Table 1).

Spawning of tunas in the Straits of Florida. The presence of larval tunas in this area indicates recent spawning, because (1) the incubation time of tuna eggs is short (Vodyanitsky, 1936; Schaefer, 1956), (2) young tunas grow rapidly (Clemens, 1956), (3) the passive displacement of eggs and newly hatched larvae by the Florida Current is probably not extensive. The last statement requires qualification. Although, in general, the currents in the Straits of Florida are relatively

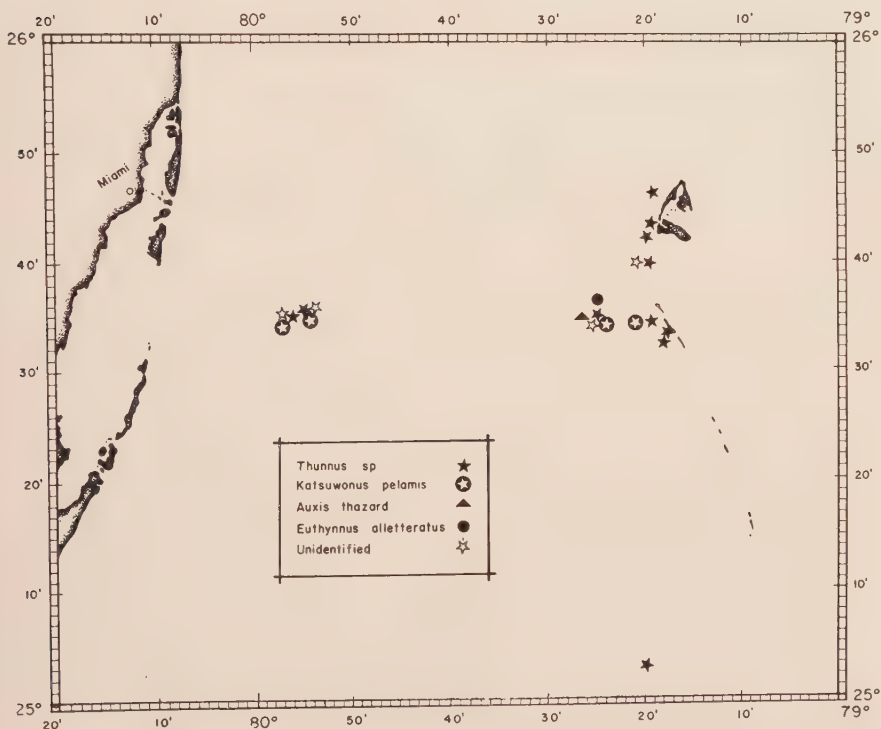


FIGURE 1. Localities of capture of larval tunas identified from The Marine Laboratory collection in the Florida Current.

large, most of the collections were made off Miami (Figure 1) where the speed of surface currents is considerably increased, but the speeds down the stream are not too large (Hela, 1954) and therefore the passive transportation into the area of capture could not be very rapid.

From the number of different larvae captured in the Straits of Florida it appears that the spawning of *Thunnus* sp. or spp. is much more extensive than that of *Katsuwonus pelamis*, *Auxis thazard* and *Euthynnus alletteratus*.

The dates of captures given in Table 1 provide a basis for inference as to the time of spawning of the several tunas in the Straits of Florida. The months in which larval forms were collected in some or all of the years represented in the collections are as follows:

	March	April	May	June	July	Aug.	Sept.	Oct.
<i>Thunnus</i> sp. or spp.	x		x	x	x	x	x	x
<i>Katsuwonus pelamis</i>		x	x		x	x		x
<i>Auxis thazard</i>			x	x		x		
<i>Euthynnus alletteratus</i>				x				

The unidentified larval tunas were collected between March and August. From the foregoing it appears that at some time or other during the period from March through October several of the tunas in the waters of Straits of Florida engage in reproductive activity.

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PRELIMINARY NOTES ON THE LIFE-HISTORY OF *MESOSTEPHANUS APPENDICULATOIDES* (PRICE, 1934) LUTZ, 1935¹

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ABSTRACT

The life history, both experimental and natural, of *M. appendiculatoides* is discussed.

Price (1934) described *Prohemistomum appendiculatoides* from the small intestine of the pelican, *Pelecanus occidentalis occidentalis*, collected at Levantade Keys, Samaná Bay, in the Dominican Republic. He deposited specimens in the U. S. National Museum, Helminthological Collection; holotype, No. 8701; paratypes, No. 8702. Lutz (1935) created the genus *Mesostephanus* with *M. fajardensis* (Price, 1934) as type species and placed *Prohemistomum appendiculatoides* in the same genus. The same worker believed that *Cercaria utriculata* from the marine snail, *Cerithium* sp., belonged to the genus *Mesostephanus*. Hutton and Sogandares (*in press*) reported *M. appendiculatoides* from the brown pelican, *Pelecanus occidentalis carolinensis* Gmelin, collected from the west coast of Florida in the vicinities of Boca Ciega Bay and Gasparilla Sound. They carried out feeding experiments with laboratory-raised animals as definitive hosts and concluded that the metacercarial stage of *Mesostephanus appendiculatoides* occurred in the striped mullet, *Mugil cephalus* L., the fan-tail mullet, *M. trichodon* Poey, and the white mullet, *M. curema* Cuvier and Valenciennes. Also, they stated that a cyathocotyloid cercaria from the marine snail, *Cerithium muscarum* Say, was suspected to be the larva of *Mesostephanus appendiculatoides*.

We obtained juvenile mullet approximately one to one and one-half inches in total length from Bayboro Harbor, Tampa Bay. These fish were maintained in aerated but non-circulating sea water for two months. Periodically, during this time, specimens of these mullet were examined for encysted trematodes, but none were observed. At the end of the two months the mullet were exposed to the cyathocotyloid cercaria (Fig. 1) from *Cerithium muscarum*. Specimens of this cercaria encysted in the muscles throughout the body. When exposed to large numbers of this cercaria mullet were killed within ten minutes to two

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²Contribution Number 28.

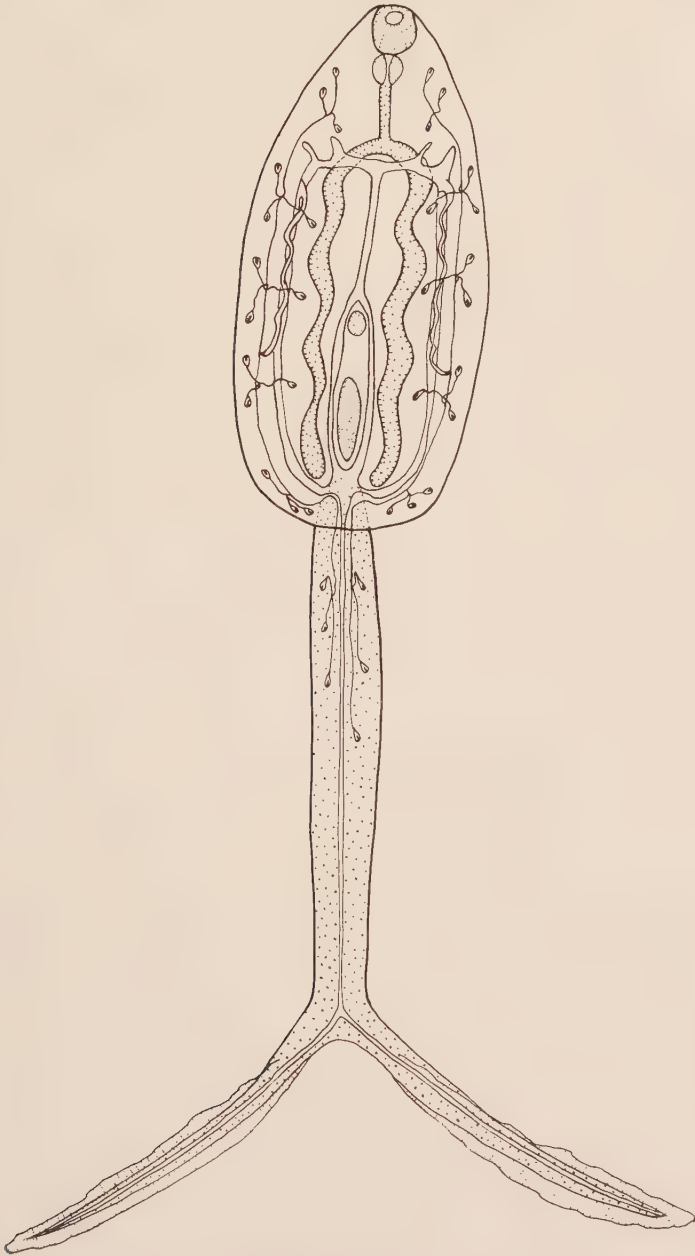


FIGURE 1. Free hand sketch of cyathocotylid cercaria from *Cerithium muscarum* Say showing excretory system.

hours, small petechial hemorrhages being observed on the body surface of these mullet. The excretory formula for the cercaria is $2[(3+3+3) + (3+3+3)]$, with the last three flame cells on each side being located in the tail stem. Two weeks after exposure one experimentally infected mullet was fed daily to a suckling opossum for three consecutive days. On the fourth day the opossum was sacrificed. Specimens in various stages of development and easily identified as *Mesostephanus appendiculatoides* were found in the anterior one-third of the intestine.

Thus, the life-cycle of *M. appendiculatoides* may be briefly stated as follows:

	<i>Experimental Cycle</i>	<i>Natural Cycle</i>
First Intermediate Host:	the marine snail, <i>Cerithium muscarum</i> Say	Same
Second Intermediate Hosts:	mullet, presumably <i>Mugil cephalus</i> L.	<i>M. cephalus</i> , <i>M. trichodon</i> , and <i>M. curema</i>
Definitive Hosts:	opossum, <i>Didelphis</i> <i>marsupialis</i> L.	the brown pelican, <i>Pelecanus occidentalis</i> <i>carolinensis</i> Gmelin

We have also found specimens of *Mesostephanus appendiculatoides* in a black-crowned night heron, *Nycticorax nycticorax hoactli* (Gmelin), hatched from the egg and fed mullet flesh, in a ring billed gull, *Larus delawarensis* Ord. and in a raccoon, *Procyon lotor* (L.), captured alive in the field and fed mullet flesh in the laboratory.

This is the first life-cycle of a member of the genus *Mesostephanus* to be elucidated experimentally.¹ A more complete report on the life-history, including descriptions of the adult, metacercaria, cercaria, and sporocysts, of *M. appendiculatoides* is to be published elsewhere.

We are indebted to Raymond Williams and William Guild, both of St. Petersburg, for supplying us with a mother opossum bearing suckling young.

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¹Since submitting our paper we have learned that Myer (unpublished doctoral dissertation, Ohio State University) has described the life history of a second species of *Mesostephanus*.

A NEW GOBIID FISH FROM THE EASTERN GULF OF MEXICO

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ABSTRACT

Coryphopterus punctipectophorus is described from specimens taken in the Gulf of Mexico off Pinellas County, Florida, in depths of 62 to 120 feet.

INTRODUCTION

In the course of collecting on the rocky reefs off the coast of Florida in the Tampa Bay area specimens were obtained of a goby which seemed most closely allied to *Coryphopterus glaucofraenum* (Gill). During the spring of 1959, an informal meeting was held with Drs. C. Richard Robins and James E. Böhlke for the purpose of evaluating the species of western Atlantic gobies of the genus *Coryphopterus*. Our findings indicated some confusion as to the number of species present, but we believed that we were able to allocate the nominal forms correctly. These are *Gobius glaucofraenum* Gill, *Lophogobius pallidus* Parr, *Gobius translucens* Nichols and *Ctenogobius tortugae* Jordan. Several lots of specimens from the Bahamas and one lot from the Gulf of Mexico off the Tampa Bay area appeared to represent undescribed species. As none of us was willing to undertake a revision of *Coryphopterus*, I decided to describe the new form from Florida without reference to the other species, described or undescribed, except to note particulars of its coloration in which it differs from all known western Atlantic gobies.

Coryphopterus punctipectophorus n. sp.

FIGURE 1

Holotype.—ANSP 90103, a female, 42.2 mm standard length, collected in the Gulf of Mexico approximately 15 miles offshore 240° from Johns Pass, Madeira Beach, Pinellas County, Florida, at a depth of 62 feet on September 14, 1958, by V. G. Springer and R. T. Kirk, using rotenone. Original field number: VGS 58-232.

Paratypes.—USNM 179307, a female, 30.1 mm. standard length, collected with the holotype; VGS 58-236 (in the Ichthyology Collection of the Florida State Board of Conservation Marine Laboratory), a male, 38.4 mm standard length, collected by V. G. Springer and R. T. Kirk on September 21, 1958, at approximately the same

¹Contribution No. 32.

locality as the holotype; CNHM 62777, three females, approximately 28, 30, and 34 mm standard length, collected by the U.S. Fish and Wildlife Service vessel SILVER BAY, at station 54 (28°09' N and 83°50' W) at a depth of 120 feet on July 16, 1957, in poor condition. *Diagnosis*.—This species is readily recognized from all other western Atlantic gobies by the delicate spotting on its body associated with

TABLE 1
COUNTS AND MEASUREMENTS ON TYPE MATERIAL OF *Coryphopterus punctipictophorus* (MEASUREMENTS ESTIMATED TO THE NEAREST 0.1 MM. THE LAST DORSAL AND ANAL RAYS ARE SPLIT TO THE BASE.)

	ANSP 90103	USNM 179307	VGS 58-236	CNHM 62777	CNHM 62777	CNHM 62777
Sex	♀	♀	♂	♀	♀	♀
Dorsal	VI,I,10	VI,I,10	VI,I,10	VI,I,10	VI,I,10	VI,I,10
Anal	I,9	I,9	I,9	I,9	I,9	I,9
Pectoral (Left/Right)	18/19	18/18	20/20	18/19	19/19	19/18
Branched Caudal Rays	12	13	12	13	—	13
Oblique Scale Rows Above						
Lateral Line	22	22	23	—	—	—
Standard Length	42.2	30.1	38.4	approx. 30	approx. 34	approx. 28
Tip of Snout to Upper						
Angle of Opercle	12.1	8.5	10.9			
Snout Length	3.3	2.0	2.6			
Eyeball Length	3.8	2.6	3.2			
Maxillary Length	4.9	3.1	4.5			
Predorsal Length	14.5	10.5	12.8			
Preanal Length (from Tip						
of Lower Jaw)	24.0	17.0	21.5			
Depth at Dorsal Origin	10.0	6.5	8.0			
Least Depth Caudal						
Peduncle	5.9	4.0	5.1			
Anal Spine Length	3.8	3.0	3.7			
1st Anal Ray Length	4.8	3.6	4.2			
9th Anal Ray Length						
(Anterior Branch)	10.1	8.0	9.9			
1st Dorsal Spine Length	5.8	4.6	5.2			
2nd Dorsal Spine Length	6.2	5.0	5.8			
3rd Dorsal Spine Length	7.0	5.3	6.1			
4th Dorsal Spine Length	7.0	5.4	6.5			
5th Dorsal Spine Length	6.0	4.5	6.0			
6th Dorsal Spine Length	4.0	2.9	3.8			
1st Dorsal Ray Length	7.0	5.1	6.0			
10th Dorsal Ray Length						
(Anterior Branch)	9.1	7.5	10.0			
Longest Caudal Ray Length	13.1	9.2	11.2			
Longest Pectoral						
Ray Length	11.6	8.9	11.6			

a very pronounced spot in the ventral prepectoral region.

Description.—(See also Table 1) A small species of goby with large, weakly ctenoid scales on its sides, venter, prepectoral and prepelvic regions. No scales present on sides of head or predorsal region. A low dermal fold in the midline before the dorsal fin.

Teeth in lower jaw consisting of an outer row of moderate and uniformly sized canines followed by two or three rows of much

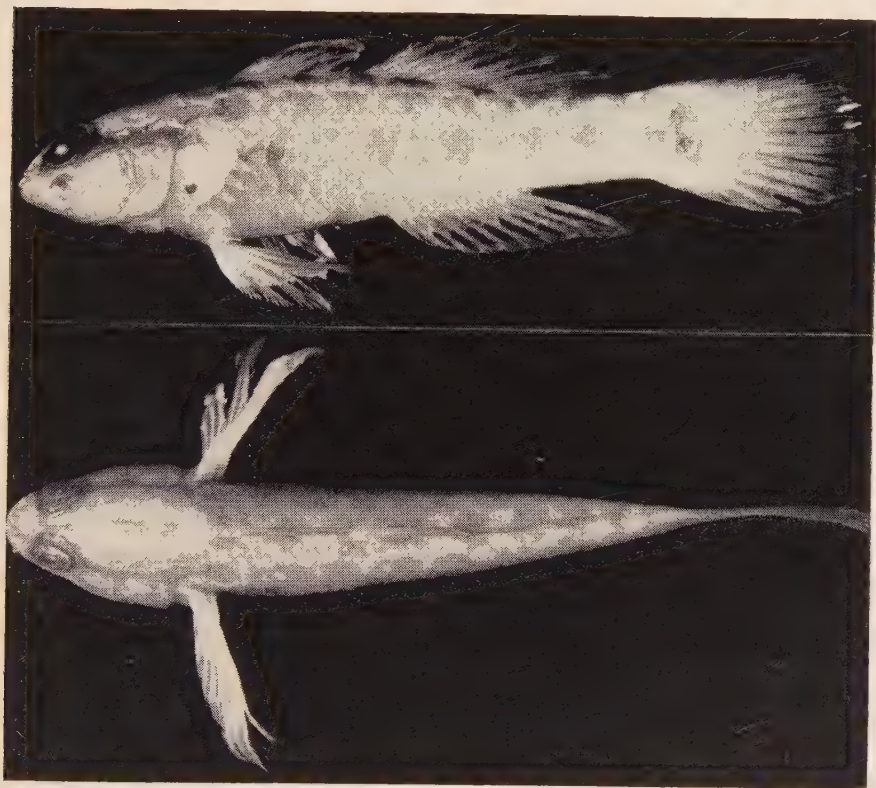


FIGURE 1. Left Lateral and Dorsal Views of the Holotype of *Coryphopterus punctipectophorus* (ANSP 90103).

smaller canines which are followed by an inner row of canines slightly smaller than the outer row. Teeth in upper jaw similar to those of lower. No teeth on vomer, palatines or pterygoids.

Color of freshly killed specimens (holotype and associated paratype): pectoral, pelvic, and anal fins immaculate. Dorsal fin with

a buff band distally which is darker on anterior portion of fin; below this band is a thin immaculate band followed by an irregular light coral pink band on the dorsal base. This latter band interrupted with light areas. Caudal fin spotted dorsally and ventrally with coral pink. Two coral pink spots on base of caudal separated by a white area. A well-developed brown spot ventrally in the prepectoral area. This spot composed of a group of closely arranged melanophores. Ventral areas of body white. Ground color of sides white. A row of dusky light buff spots on dorsal contour followed ventrally by ground color, then a row of coral pink spots separated by white and buff, then another row of coral pink spots larger than the previous row followed by the ground color (the spots are represented by darkened areas in Figure 1). Predorsal region with three longitudinal light orange lines. A pale orange line behind eye running slightly dorsally, another of same color extending from beneath eye across opercle and over dorsal pectoral base. These last two lines margined with black. A U-shaped pale orange line with the base directed anteriorly on snout.

Habitat.—Although only three specimens were obtained by myself, I saw many others. The species inhabits holes near the base of a rocky reef. It was never seen more than a few inches from one of these holes. The area surrounding the holes is covered by a fine silt which is raised in a cloud when a specimen darts into its hole.

Etymology.—The name *punctipectophorus* refers to the spot on the base of the pectoral fin.

A NEW SPECIES OF SAWSHARK, *PRISTIOPHORUS SCHROEDERI*, FROM THE BAHAMAS

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ABSTRACT

Three specimens, 38.3, 64.5, and 80.5 cm in total length, representing the first of the family Pristiophoridae known from the Western Hemisphere were collected from 350 fathoms in the Santaren Channel (the type locality) and from 500-520 fathoms north of Little Bahama Bank, and constitute the type series. In the diagnosis these are compared with the 4 other known species of the genus *Pristiophorus* and the single known species of the genus *Pliotrema*. The comparisons are based on examination by the authors of specimens in the collections of the U.S. National Museum, the Museum of Comparative Zoology at Harvard, and the British Museum (Natural History). An elaboration of the first 5 vertebrae common to the family and unique among sharks is reported.

INTRODUCTION

Three sawsharks were recently collected as an incidental product of exploratory fishing operations carried out by the U.S. Bureau of Commercial Fisheries. One was taken from the Santaren Channel, southeast of Florida, and two were from the Atlantic, just north of Little Bahama Bank. The specimens are the only sawsharks known from the Western Hemisphere and are of unusual interest because they represent the Pristiophoridae, a poorly known family of great antiquity.

Compared with many other shark groups, the sawsharks are relatively small and are externally similar, at least in the possession of a sawlike extension of the snout, to the sawfishes (family Pristidae). The sawfishes, however, inhabit the shallow areas of tropical and subtropical seas, attain lengths as great as 20 feet, and are ray-like in basic, structural plan. In contrast, the sawsharks are usually found in moderately deep water, are not known to reach lengths of over 5 feet, and possess the basic structural plan of sharks.

We have examined 3 preserved specimens of sawsharks from the collection of the U.S. National Museum, 6 from the collection of the Museum of Comparative Zoology at Harvard College, and 3 in the British Museum (Natural History) collection including the types of

¹Fishery Methods and Equipment Specialists, Bureau of Commercial Fisheries, Washington, D. C., and Pascagoula, Mississippi.

Pliotrema warreni Regan 1906 and *Pristiophorus owenii* Günther 1870. Adding the three American specimens, the available series of 15 spirit-preserved specimens representing 6 species is still obviously inadequate for a satisfying analysis.

DISTRIBUTION AND CHARACTERISTICS OF THE FAMILY

Before our specimens were collected, sawsharks were known only from the offings of Japan, the East Indies, the Philippine Islands, Australia, and the Southeast coast of Africa. Published accounts of sawsharks are few, and comparatively few specimens are available for study in the museum collections of America and Europe. One species, *Pliotrema warreni* Regan 1906, from the coast of Natal, has 6 gill openings and is the only representative of its genus. All other species of the family belong to the genus *Pristiophorus* Müller and Henle 1837 and have 5 gill openings. *Pristiophorus cirratus* (Latham) 1794, the type species, has been recorded from New South Wales, Victoria, Tasmania, South Australia, the Philippines, and South Africa (Fowler 1941). Barnard (1925) notes that Gilchrist regarded the South African record as doubtful, and as probably based on a specimen of *Pliotrema warreni*. *Pliotrema* is commonly taken by trawlers fishing in waters from the Cape to beyond Delgoa Bay in depths from 20 to 200 fathoms (Smith 1949). Whitley (1940) reports that sawsharks are commonly caught by trawlers in Australia—*Pristiophorus cirratus* in depths from 10 to 170 fathoms and *Pristiophorus nudipinnis* Günther 1870 from 20 to 90 fathoms.

Possibly, sawsharks are widely distributed in depths of more than 200 fathoms. This is suggested by our specimens from 350 to 520 fathoms, considerably deeper than waters from which other species have been recorded. Some apparent discontinuities in distribution may disappear as the fauna of the deeper water becomes better known. We have, therefore, examined the possibility that there is only one species of *Pristiophorus* of world-wide distribution, or at least, fewer species than are generally recognized. The weight of evidence available to us now, however, forces us to conclude that there are several species, and that the American specimens are representative of a new species which is described here.

In addition to the species already mentioned, we recognize, tentatively, *Pristiophorus japonicus* Günther 1870 and *Pristiophorus owenii* Günther 1870.

Bigelow and Schroeder (1948) place the Pristiophoridae as the sole

family in suborder Pristiophoroidea on the basis of the beak-like snout with lateral teeth and, more particularly, the presence of a separate antorbital bar from which the upper jaw is suspended. This



FIGURE 1. Ventral, lateral, and dorsal aspects of *Pristiophorus schroederi*, the holotype, USNM 185946. Photographs by Smithsonian Institution

suspension is effected by a broad ligament in addition to an articulation to the cranium. The antorbital bar is unique among sharks.

X-rays of our specimens revealed an elaboration of the first 5 vertebrae in support of the cranium (Fig. 2). Because no reference to such a structure was found in the literature, additional X-ray pictures were made of other species of *Pristiophorus*—*cirratus*, *nudipinnis*, and *japonicus*—and an X-ray of the type specimen of *Pliotrema warreni* was furnished by the British Museum (Natural History) through Dr. Ethelwynn Trewavas. All indicate that the vertebral elaboration is consistently present in sawsharks. No variations were observed in these structures. X-rays of examples of the presumably

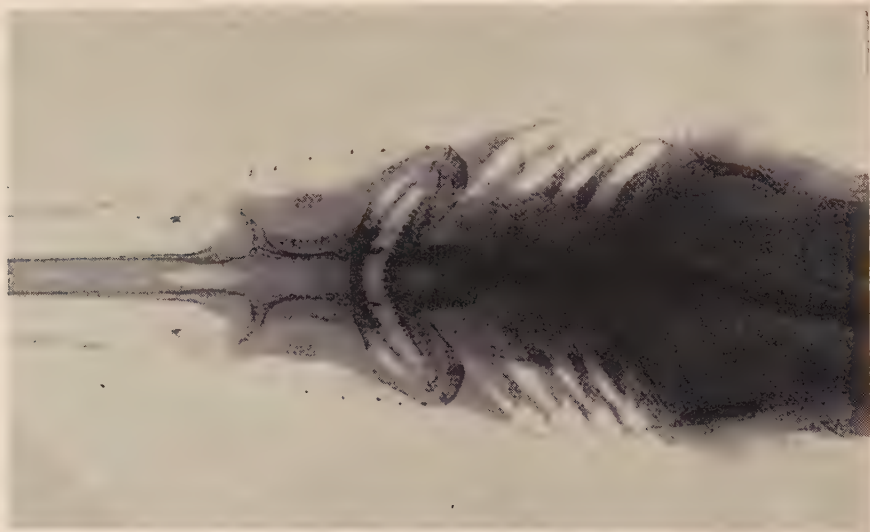


FIGURE 2. X-ray print of the head region of *Pristiophorus schroederi*, USNM 185947, showing the basket-like support of the cranium formed by extensions of the first five vertebrae. X-ray photograph by Ichthyological Laboratory, Bureau of Commercial Fisheries.

related families, Squalidae and Pristidae, failed to show a trace of similar vertebral elaborations, but weakly calcified and simpler structures, appearing as rod-like extensions of vertebrae, were noted in an X-ray of *Squatina dumeril* Lesueur.

Partial dissection of one of the examples of the new species of sawshark verified X-ray observations that the first five vertebrae of the Pristiophoridae are greatly modified to support the cranium and to

limit the lateral flexing of the head and saw. Lateral processes of the first vertebra articulate along the entire width of cranium by broad flattened surfaces and with similar processes of the second vertebra. These flattened processes are arranged to permit some bending of the vertebral column, but at the same time they must serve to restrict bending to moderate limits. They may also be essential reinforcing structures if twisting of the head is a normal activity, a possibility suggested by muscle arrangements. The processes decrease progressively in their lateral extent from the 1st to the 5th vertebra (Fig. 2), but at the same time they increase in anterior-posterior thickness. The centrum of the second vertebra is enlarged and convex on its anterior face and fits into a corresponding concavity on the posterior face of the first vertebra.

Our examination of the structures is not complete. An anatomical study is planned, but further details are not necessary to point out that this unique arrangement of vertebrae provides an added reason for careful examination of the phylogenetic position of the sawsharks. It should be noted that the two families Pristiophoridae and Squatinidae are unique among the sharks in having an axillary border to the pectoral fins. This is very short in the Pristiophoridae, but somewhat more strongly developed in the Squatinidae.

A significant feature of the sawsharks is the slight compression of their bodies and the strong flattening of their heads. The compression of the body is notable in fresh specimens or in specimens quickly and adequately fixed in formalin. Evidently the junction of the vertical plane of the body with the horizontal plane of the head is a point in need of structural reinforcement.

The six species making up the Pristiophoridae are quite similar to one another in body form, fin shape and position, and in the general structure of the saw-like rostrum. The limited material indicates that the sawsharks reach maturity at a total length of about 1 meter. Whitley (1940) reports that *P. cirratus* reaches a length of over 4 feet and that the species is viviparous. Lengths up to approximately 5 feet are mentioned by Fowler (1941) from the literature.

GENUS *Pristiophorus* Müller and Henle

Pristiophorus Müller and Henle, Sitz. Berlin Akad. Wiss. p. 116, 1837, (Atypic. Type, *Pristis cirratus* Latham, Trans. Linn. Soc. London, vol. 2, p. 281, pl. 26, fig. 5, pl. 27, 1794; type locality, New Holland); Arch. Naturg., pt. 1, p. 399, 1837. Type species *Pristis cirratus* Latham.

Pristiophorus schroederi sp. nov.

Figs. 1, 3, and 5; Table 1

Holotype.—USNM 185946, a young female 383 mm, in total length, taken in a beam trawl at a depth of 350 fathoms at COMBAT² Station 449, 24°05' North Latitude, 79°46' West Longitude, about 15 miles east of Dog Rocks, Cay Sal Bank, on June 24, 1957.

Range.—Known only from the holotype and two other larger specimens collected at SILVER BAY² Station 445, at depths of 500 to 520 fathoms north of Little Bahama Bank, 28°03' North Latitude, 78°46' West Longitude, on June 9, 1958.

Description of the Holotype.—Head flattened. Body slightly compressed (slightly deeper than wide, when in formalin fixation before being transferred to alcohol), tapering slightly to precaudal portion which is nearly square in cross section. Ventral surface of precaudal region flat with lateral keels marking the junctions of the lateral and ventral surfaces and extending from the tips of the pelvics as far back as the lower caudal flap. Caudal axis little elevated.

Gill slits five, nearly equal in length, the fifth crossing the point of insertion of the pectoral and extending approximately equal distances above and below it.

Rostrum, sawlike, thin. Length of the rostrum from forward edge of mouth to tip slightly less than one-third the total length. A pair of barbels originating from the ventral surface of the rostrum near its lateral edges approximately equidistant from the tip of the rostrum and the forward edge of the mouth. Barbels scaled, circular in cross section at their bases, but flattened and oval in cross section throughout most of their length, and reaching about nine-tenths the distance to the mouth.

Rostrum with a row of strong unserrated spines along each lateral margin, and two rows of shorter thorn-like spines on the ventral surface near the lateral edges extending from the tip to the nasal openings. Lateral rostral spines very slightly curved posteriorly, these spines alternating long and short with few exceptions, the longer 5 to 7 mm and the shorter 2 to 3 mm, 47 or 48 spines on either side, each lateral rostral series continued along the length of the antorbital bar by 10 to 20 short recurved spines. Ventral rostral spines, excepting only a few larger spines at the tip of the rostrum and the last spines

²The commercial fishing vessels COMBAT and SILVER BAY were chartered for exploratory fishing by the Bureau of Commercial Fisheries.

before the nasal apertures, short, about 0.7 to 1.5 mm, stout, strongly recurved.

Mouth little arched. Upper jaw teeth with a single low smooth cusp, in 36 rows. Lower jaw teeth similar, in 32 rows. Nasal openings oval, surrounded by a narrow raised rim, and with a pointed scroll-like flap. Eyes large, horizontal diameter of the orbits about two times the vertical diameter, pupil round. Spiracles large, their lengths about two-thirds the length of the orbits, their anterior external rims with a comb-like structure. Spiracles opening directly above the corners of the mouth into the buccal cavity. Roof and floor of the mouth with numerous papillae.

A post cranial depression located between the forward edges of spiracles; this depression with a pair of external openings to thick walled ducts leading toward the foramen magnum.

No anal fin. Two dorsal fins approximately equal in size, the first



FIGURE 3. Dermal denticles from the dorsal surface of *Pristiophorus schroederi*, holotype, USNM 185946. Photograph by Pascagoula Exploratory Fishing Base, Bureau of Commercial Fisheries.

originating about half way from the tip of the rostrum to the tip of the caudal fin, the origin of the second dorsal posterior to the tips of the pelvics. Pectoral fins large, their inner margins curved inward toward the bases of the fins to form short axillary borders. Pelvic fins separated from one another posterior to the anus as in the rays.

Dermal denticles of the dorsal surface of the body but little overlapping, typically with three points directed upward and posteriorly, the central point much the longest, acuminate, a strong and high central ridge extending from the base to the tip of the central point, lateral ridges weak; fins fully scaled, rostrum partially covered with scales. Ventral scales typically leaf like, without accessory points or ridges.

Color light gray above, whitish below, anterior edges and tip of dorsal and caudal fins dark, posterior edges of pectorals very narrowly edged with white, distal edges of pelvics indistinctly edged with white. A brownish stripe on either side of the midline of the rostrum. Bases of tentacles dark; lateral rostral spines light brown, ventral rostral spines and lateral spines of the antorbital dark brown.

Diagnosis, with notes on other species of sawsharks.—*Pliotrema warreni* is sharply set off from species of *Pristiophorus* because it has 6 instead of 5 gill openings and because the larger lateral spines of the rostrum in *Pliotrema* are serrate along their posterior margins while these spines are smooth in *Pristiophorus*. The bases of the jaw teeth of *Pliotrema* have 3 to 6 short but distinct ridges, somewhat stronger on the upper jaw teeth. These ridges are quite indistinct or absent in *Pristiophorus*.

From the short series available to us we are unable to establish any outstanding differences between the species of sawsharks based on morphometrics. Some points of divergence appear to be merely the result of differential growth. Our material does suggest (table 1) that *P. schroederi* has a proportionately longer rostrum than other species. It is notably longer than the rostrum of *P. owenii* and *P. nudipinnis*, but only slightly longer than the rostrum of *P. cirratus*. The rostrum of *P. japonicus*, the remaining species of *Pristiophorus*, appears from our material to be intermediate in length. Garman (1913) on the basis of measurements made on two specimens, MCZ 1283 and MCZ 1045, states that there is an indication that proportional changes during growth include lengthening of the rostrum. We have re-measured the specimens to which Garman refers, but the addition of measurements of a third and larger specimen, USNM 99500, changes

TABLE 1
MEASUREMENTS AND TOOTH ROW COUNTS FOR SPECIMENS
OF *Pristiophorus* AND *Pliotrema*.

Species, sex, length, and museum number of specimen.	Number of rows of teeth in upper jaw.	Distance between 1st and 2nd dorsal fins.	Measurement in per cent of the total length Tip of snout to:			
			Orbit	Nostril	Mouth	1st dorsal fin
<i>Pristiophorus schroederi</i> , yng. fem. 383 mm. USNM 185 946, holotype.	36	12.5	28.7	26.9	31.9	49.6
<i>Pristiophorus schroederi</i> , imm. male 645 mm. USNM 185 947	33	11.9	28.7	27.7	30.7	49.8
<i>Pristiophorus schroederi</i> , female 805 mm. USNM 185 947	36	11.9	28.6	27.0	30.5	49.6
<i>Pristiophorus owenii</i> , yng. female, 323 mm. BMNH	33	11.8	20.7	19.8	22.6	45.8
<i>Pristiophorus nudipinnis</i> , male, prob. ad., 1040 mm. BMNH, syntype	35	16.8	20.5	21.7	22.6	45.4
<i>Pristiophorus nudipinnis</i> , embryo female, 315 mm. BMNH	—	—	23.5	27.0	—	—
<i>Pristiophorus nudipinnis</i> , female, 1000 mm. approx. MCZ 665	33	—	22.5 approx.	—	—	—
<i>Pristiophorus cirratus</i> , female, 557 mm. MCZ 38611	39	13.3	25.3	22.4	28.6	48.5
<i>Pristiophorus cirratus</i> , female, 600 mm. MCZ 38611	39	14.3	25.3	24.5	28.3	51.2
<i>Pristiophorus cirratus</i> , female, 965 mm. MCZ 38611	48	16.4	24.9	23.4	26.6	51.3
<i>Pristiophorus cirratus</i> , female, dried, distorted, 1100 mm. approx. USNM 59842	39	—	—	—	—	—
<i>Pristiophorus japonicus</i> male emb. 304 mm. MCZ 1283	—	11.2	22.0	21.1	25.7	46.1
<i>Pristiophorus japonicus</i> ad. male, 1072 mm. USNM 99500	56	17.3	23.7	22.2	25.6	47.6
<i>Pristiophorus japonicus</i> female, 865 mm., MCZ 1045	46	14.0	26.8	25.4	28.7	47.2
<i>Pliotrema warreni</i> , female, 800 mm. BMNH, type.	43	13.9	—	25.6	28.3	48.3
<i>Pristiophorus</i> sp. not identified, broken rostrum, portion missing, projected length about 490 mm. USNM 151 231	31	—	—	—	—	—

the picture of increasing rostral length with age (table 1). Furthermore, measurements included for the other species do not support the view that the rostrum increases proportionally in length with age.

In the descriptions of species of *Pristiophorus* provided by Günther (1870) the number of rows of teeth in the upper jaw are considered diagnostic. Garman (1913), Fowler (1941), and Whitley (1940) also use the number of rows of upper jaw teeth as diagnostic features. Jordan and Fowler (1903) do not mention the number of tooth rows in their account of the Japanese form (*P. japonicus*). Tooth rows are difficult to count, and our counts shown in Table 1 agree only approximately with the counts given in earlier reports, although we suspect that we are dealing in part with the same specimens. In common with earlier writers, we have some doubt as to the adequacy of tooth counts for separation of species. On the basis of our counts, however, the available series show that *P. schroederi*, with 33 to 36 rows, is separable from *P. cirratus* and *P. japonicus* with 39 to 56 rows. Counts for *P. nudipinnis* fall within the range given for *P. schroederi*.

Pristiophorus owenii, although known only from the type, a juvenile without locality data, appears to us to represent a species that is quite distinct from other described forms. The type is in remarkably fine condition and is unique and trenchantly different from other specimens in the regularity and even length of its lateral rostral spines. Günther cites the number of rows of upper jaw teeth as 41. This may have led Garman to mention the specimen in a note in his account of *P. cirratus*, although he did not place it in the synonymy of that species. Fowler placed *owenii* in the synonymy of *P. nudipinnis*, perhaps basing his decision on a recount of the number of tooth rows of the type of *owenii* (our determination shows 33). We found that *owenii* and *nudipinnis* are similar in having short rostrums, but that the fins of *owenii* are fully scaled; whereas, in large examples of *nudipinnis*, there are naked patches. The important differentiating character of *owenii*, however, is the even length of the rostral spines in contrast with McCulloch's (1911) figure of a young example of *nudipinnis* with alternating long and short spines. *Pristiophorus schroederi* differs from *owenii* in having one or more short lateral rostral spines between the long spines.

The dermal denticles (scales) have been described in most of the earlier accounts of sawsharks. Definition of species on this basis is difficult because the extent to which the dermal denticles are subject to change in form with increasing age has not been determined for



FIGURE 4. Upper. Typical dermal denticles from the dorsal surface of a large example of *Pristiophorus cirratus*. USNM 59842 (x34). Lower. Typical dermal denticles from the dorsal surface of a large specimen of *Pristiophorus japonicus*. USNM 99500 (x34). Photographs by Pascagoula Exploratory Fishing Base.

this family. There are indications, at least in the available series of *P. cirratus* and *P. nudipinnis*, that larger examples are characterized by a reduction in the height and prominence of the ridges and points of the denticles, and by an increase in the number of ridges.

P. schroederi and *P. nudipinnis* represent extremes in the divergence of denticle structure. The typical denticles of the dorsal surface in the type *P. schroederi*, the smallest of our three specimens, are slender, somewhat leaflike, bear a very long slender point directed upward and backward, and have two shorter accessory points on either side. A prominent, high, thin ridge extends from the base to the tip of the central point of the denticle; and lower, less prominent, ridges extend to the tips of the lateral points. In the larger examples of *P. schroederi*, typical denticles are 3-pointed with complete ridges; but occasional denticles have single points, and there is some reduction in the length of points. At the other extreme, typical, dorsal, dermal denticles of the larger examples of *P. nudipinnis* are thickened, somewhat broader than long, roughly diamond shaped, paved, and bear 3 to 6 low ridges

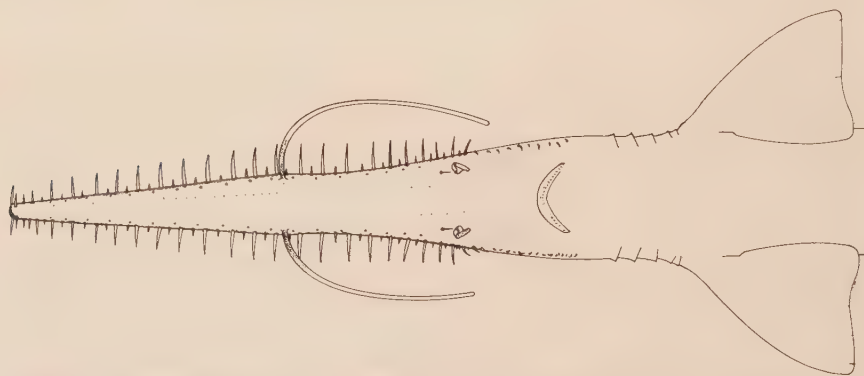


FIGURE 5. Ventral aspect of the head region of *Pristiophorus schroederi*, holotype, USNM 185946.

on only the basal portion. The dermal denticles of *P. cirratus* are similar to those of *P. nudipinnis*. The smaller examples of *cirratus* and *nudipinnis* have more extensive development of the single central ridge but a single posteriorly directed point on each denticle.

The dermal denticles of large specimens of *P. japonicus* typically have a single strong central ridge and a single posteriorly directed point which is not acuminate as it is in *P. schroederi*. Smaller examples of *japonicus* have more slender and longer points, but usually only one

per scale. Lateral ridges are usually absent or quite indistinct.

P. owenii has narrow leaflike denticles with a single point which is not acuminate.

In summary, the 3-pointed denticles distinguish *P. schroederi* rather easily from all other species of *Pristiophorus*, but denticle structure is a less satisfying means for distinguishing the three oriental species from one another.

The absence of scales on portions of the dorsal and pectoral fins has been mentioned by earlier writers as characteristic of *P. nudipinnis*. Our examination of a fine specimen in the British Museum labeled "syntype, 1869.2.24,2, Tasmania, Schwarzchild", confirms this for that particular specimen. Scales are absent on the upper surfaces of the pectorals and the distal portions of the first and second dorsal fins. These fin portions are irregular in shape which suggests that the scales may have been rubbed off, but there is no indication in microscopic examination, of any abrasion. In another example, MCZ 665, a skin in relatively poor condition, our notes indicate that the fins are all fully scaled except for a few areas where denticles have obviously been rubbed off.

We have examined one sawshark (USNM 151 231 (10170) Philippine Islands, Apo Island (22) ALBATROSS) which has a broken rostrum with the tip missing. It has 31 rows of teeth in the upper jaw and a few of the denticles are 3-pointed. We are unable to identify it.

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